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## SEPARATION CHARACTERISTICS OF THE SUU-51/B FROM THE F-4C AIRCRAFT

Janis Kukainis

ARO, Inc.

July 1971

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**SEPARATION CHARACTERISTICS OF THE SUU-51/B  
FROM THE F-4C AIRCRAFT**

**Janis Kukainis  
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## FOREWORD

The work reported herein was sponsored by the Air Force Armament Development and Test Center (ADTC/DLGD), Air Force Systems Command (AFSC), under Program Element 64724F, Project 1120, Task 07.

The test results presented were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), AFSC, Arnold Air Force Station, Tennessee, under Contract F40600-72-C-0003. The test was conducted from April 12 to 16, 1971, under ARO Project No. PC0138. The manuscript was submitted for publication on May 26, 1971.

This technical report has been reviewed and is approved.

George F. Garey  
Lt Colonel, USAF  
AF Representative, PWT  
Directorate of Test

Joseph R. Henry  
Colonel, USAF  
Director of Test

**ABSTRACT**

A wind tunnel test was conducted using 0.05-scale models to study the separation characteristics of the SUU-51/B from the F-4C aircraft. The separation trajectories were initiated from the left-wing inboard pylon station utilizing the Triple Ejection Rack and from the centerline pylon utilizing the Multiple Ejection Rack. The flight conditions simulated were Mach numbers from 0.66 to 0.90 at an altitude of 5000 ft. Parent aircraft dive angles of 0, 30, and 45 deg were simulated.

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## NOMENCLATURE

BL	Aircraft buttock line from plane of symmetry, in., model scale
b	Store reference dimension, ft full scale
$C_A$	Store axial-force coefficient, axial force/ $q_\infty S$
$C_m$	Store pitching-moment coefficient, referenced to the store center of gravity (cg), pitching moment/ $q_\infty S b$
$C_{m_q}$	Store pitch-damping derivative, $dC_m/d(qb/2V_\infty)$
$C_n$	Store yawing-moment coefficient, referenced to the store cg, yawing moment/ $q_\infty S b$
$C_{n_r}$	Store yaw-damping derivative, $dC_n/d(rb/2V_\infty)$
FS	Aircraft fuselage station, in., model scale
$F_Z$	MER/TER ejector force, lb
H	Pressure altitude, ft
$I_{xx}$	Full-scale moment of inertia about the store $X_B$ axis, slug-ft <sup>2</sup>
$I_{xz}$	Full-scale product of inertia, $X_B$ - $Z_B$ axis, slug-ft <sup>2</sup>
$I_{yy}$	Full-scale moment of inertia about the store $Y_B$ axis, slug-ft <sup>2</sup>
$I_{zz}$	Full-scale moment of inertia about the store $Z_B$ axis, slug-ft <sup>2</sup>



$M_\infty$	Free-stream Mach number
$\bar{m}$	Full-scale store mass, slugs
$p_\infty$	Free-stream static pressure, psfa
$q$	Store angular velocity about the $Y_B$ axis, radians/sec
$q_\infty$	Free-stream dynamic pressure, $0.7 p_\infty M_\infty^2$ , psf
$r$	Store angular velocity about the $Z_B$ axis, radians/sec
$S$	Store reference area, $\text{ft}^2$ , full scale
$t$	Real trajectory time from initiation of trajectory, sec
$V_\infty$	Free-stream velocity, ft/sec
$WL$	Aircraft waterline from reference horizontal plane, in., model scale
$X$	Separation distance of the store cg parallel to the flight axis system $X_F$ direction, ft, full scale measured from the prelaunch position
$X_{cg}$	Full-scale cg location, ft from nose of store
$X_L$	Ejector piston location relative to the store cg, positive forward of store cg, ft full scale
$Y$	Separation distance of the store cg parallel to the flight axis system $Y_F$ direction, ft, full scale measured from the prelaunch position
$Z$	Separation distance of the store cg parallel to the flight-axis system $Z_F$ direction, ft, full scale measured from the prelaunch position
$Z_E$	Ejector stroke length, ft, full scale
$\alpha$	Parent-aircraft or store model angle of attack relative to the free-stream velocity vector, deg
$\theta$	Angle between the store longitudinal axis and its projection in the $X_F$ - $Y_F$ plane, positive when store nose is raised as seen by pilot, deg
$\bar{\theta}$	Simulated parent-aircraft climb angle. Angle between the flight direction and the earth horizontal, deg, positive for increasing altitude
$\psi$	Angle between the projection of the store longitudinal axis in the $X_F$ - $Y_F$ plane and the $X_F$ axis, positive when the store nose is to the right as seen by the pilot, deg

## FLIGHT-AXIS SYSTEM COORDINATES

### Directions

- $X_F$  Parallel to the free-stream wind vector, positive direction is forward as seen by the pilot
- $Y_F$  Perpendicular to the  $X_F$  and  $Z_F$  directions, positive direction is to the right as seen by the pilot
- $Z_F$  In the aircraft plane of symmetry, perpendicular to the free-stream wind vector, positive direction is downward

The flight-axis system origin is coincident with the aircraft cg and remains fixed with respect to the parent aircraft during store separation. The  $X_F$ ,  $Y_F$ , and  $Z_F$  coordinate axes do not rotate with respect to the initial flight direction and attitude.

## STORE BODY-AXIS SYSTEM COORDINATES

### Directions

- $X_B$  Parallel to the store longitudinal axis, positive direction is upstream in the prelaunch position
- $Y_B$  Perpendicular to the store longitudinal axis, and parallel to the flight-axis system  $X_F$ - $Y_F$  plane when the store is at zero roll angle, positive direction is to the right looking upstream when the store is at zero yaw and roll angles
- $Z_B$  Perpendicular to both the  $X_B$  and  $Y_B$  axes, positive direction is downward as seen by the pilot when the store is at zero pitch and roll angles

The store body-axis system origin is coincident with the store cg and moves with the store during separation from the parent airplane. The  $X_B$ ,  $Y_B$ , and  $Z_B$  coordinate axes rotate with the store in pitch, yaw, and roll so that mass moments of inertia about the three axes are not time-varying quantities.

## SECTION I INTRODUCTION

This investigation was conducted in the Aerodynamic Wind Tunnel (4T) of the Propulsion Wind Tunnel Facility to obtain captive-trajectory store-separation data for the SUU-51/B store when released from various F-4C inboard and centerline multiple carriage configurations. Separation trajectories with the folded-fin configuration were initiated from the launch positions with simulated ejector forces acting on the store. If a trajectory was of sufficient length to reach the position where the fins could be deployed, the open-fin configuration was used to obtain additional data, initiating from the chosen store location along the original trajectory. The criterion for fin deployment was a clearance of at least 1.5 ft between the rack and the aft end of the store.

To simulate the separation trajectories, 0.05-scale models of the F-4C and the store were employed. The store models were attached to the Captive Trajectory System (CTS) in the 4T wind tunnel. Flight conditions simulated were Mach numbers from 0.66 to 0.90, an altitude of 5000 ft, and parent-aircraft angles of attack from 2.2 to 0.5 deg in level flight. At most test conditions, parent-aircraft dive angles of 30 and 45 deg were also simulated.

## SECTION II APPARATUS

### 2.1 TEST FACILITY

The Aerodynamic Wind Tunnel (4T) is a closed-loop, continuous flow, variable-density tunnel in which the Mach number can be varied from 0.2 to 1.3. At all Mach numbers, the stagnation pressure can be varied from 200 to 3400 psfa. The test section is 4 ft square and 12.5 ft long with perforated, variable porosity (0.5- to 10-percent open) walls. It is completely enclosed in a plenum chamber from which the air can be evacuated, allowing part of the tunnel airflow to be removed through the perforated walls of the test section.

For store separation testing, two separate and independent support systems are used to support the models. The parent aircraft model is inverted in the test section and supported by an offset sting attached to the main pitch sector. The store model is supported by the CTS which extends down from the tunnel top wall and provides store movement (six degrees of freedom) independent of the parent-aircraft model. An isometric drawing of a typical store separation installation is shown in Fig. 1, Appendix I.

Also shown in Fig. 1 is a block diagram of the computer control loop used during captive trajectory testing. The analog system and the digital computer work as an integrated unit and, utilizing required input information, control the store movement during a trajectory. Store positioning is accomplished by use of six individual d-c electric motors. Maximum translational travel of the CTS is  $\pm 15$  in. from the tunnel centerline in the lateral and vertical directions and 36 in. in the axial direction. Maximum angular

displacements are  $\pm 45$  deg in pitch and yaw and  $\pm 360$  deg in roll. A more complete description of the test facility can be found in the Test Facilities Handbook.<sup>1</sup> A schematic showing the test section details and the location of the models in the tunnel is shown in Fig. 2.

## 2.2 TEST ARTICLES

The test articles were 0.05-scale models of the F-4C parent aircraft and the SUU-51/B store. A sketch showing the basic dimensions of the F-4C parent model is shown in Fig. 3. For this test, only the left wing and fuselage centerline of the F-4C were equipped for store separation. Details and dimensions of the pylons are shown in Fig. 4. The surfaces of the fuselage centerline and wing inboard pylons are inclined at a 2.5- and 1.0-deg nose-down angle, respectively, with respect to the aircraft waterline.

The Triple Ejection Rack (TER) and Multiple Ejection Rack (MER) were mounted on the inboard and centerline pylons, respectively, and matched to the 30-in. suspension lugs of the pylons. Details and dimensions of the TER and MER are shown in Figs. 5 and 6, respectively.

Details and dimensions of the SUU-51/B store model are shown in Figs. 7, 8, and 9. A dimensional sketch of the 370-gal dummy fuel tank is shown in Fig. 10. A schematic of the TER and MER store stations and orientation is given in Fig. 11, and the weapons loading configurations for which trajectory data were obtained are shown in Fig. 12.

## 2.3 INSTRUMENTATION

A five-component, internal strain-gage balance was used to obtain the force and moment data on the SUU-51/B model. Translational and angular positions of the store model were obtained from the CTS analog outputs. An angular position indicator on the main pitch sector was used to determine the parent-model angle of attack. The MER and TER were instrumented with a touch wire at each station which aided in the positioning of the sting-mounted store model at the launch position on the rack. The system was also electrically connected to automatically stop the CTS movement if the store model or sting contacted the rack or the aircraft-model surface.

# SECTION III TEST DESCRIPTION

## 3.1 TEST CONDITIONS

Separation trajectory data were obtained at Mach numbers from 0.66 to 0.90. Tunnel dynamic pressure was 500 psf at all Mach numbers, and tunnel stagnation temperature was maintained near 100°F.

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<sup>1</sup>Test Facilities Handbook (Eighth Edition). "Propulsion Wind Tunnel Facility, Vol. 5." Arnold Engineering Development Center, December 1969 (AD864636).

Tunnel conditions were held constant at the desired Mach number and stagnation pressure while data for each trajectory were obtained. The trajectories were terminated when the store or sting contacted the parent-aircraft model or when a CTS limit was reached.

### 3.2 TRAJECTORY DATA ACQUISITION

To obtain a trajectory, test conditions were established in the tunnel and the parent model was positioned at the desired angle of attack. The store model was then oriented to a position corresponding to the store carriage location. After the store was set at the desired initial position, operational control of the CTS was switched to the digital computer which controlled the store movement during the trajectory through commands to the CTS analog system (see block diagram, Fig. 1). Data from the wind tunnel, consisting of measured model forces and moments, wind tunnel operating conditions, and CTS rig positions, were input to the digital computer for use in the full-scale trajectory calculations.

The digital computer was programmed to solve the six-degree-of-freedom equations to calculate the angular and linear displacements of the store relative to the parent aircraft pylon. In general, the program involves using the last two successive measured values of each static aerodynamic coefficient to predict the magnitude of the coefficients over the next time interval of the trajectory. These predicted values are used to calculate the new position and attitude of the store at the end of the time interval. The CTS is then commanded to move the store model to this new position and the aerodynamic loads are measured. If these new measurements agree with the predicted values, the process is continued over another time interval of the same magnitude. If the measured and predicted values do not agree within the desired precision, the calculation is redone over a time interval one-half the previous value. This process is repeated until a complete trajectory has been obtained.

In applying the wind tunnel data to the calculations of the full-scale store trajectories, the measured forces and moments are reduced to coefficient form and then applied with proper full-scale store dimensions and flight dynamic pressure. Dynamic pressure was calculated using a flight velocity equal to the free-stream velocity component plus the components of store velocity relative to the aircraft, and a density corresponding to the simulated altitude.

The initial portion of each launch trajectory incorporated simulated ejector forces in addition to the measured aerodynamic forces acting on the store. The ejector force function for the SUU-51/B store is presented in Fig. 13. The ejector force was considered to act perpendicular to the rack mounting surface. The locations of the applied ejector forces and other full-scale store parameters used in the trajectory calculations are listed in Table I, Appendix II.

### 3.3 CORRECTIONS

Balance, sting, and support deflections caused by the aerodynamic loads on the store models were accounted for in the data reduction program to calculate the true store-model

angles. Corrections were also made for model weight tares to calculate the net aerodynamic forces on the store model.

### 3.4 PRECISION OF DATA

The trajectory data are subject to error from several sources including tunnel conditions, balance measurements, extrapolation tolerances allowed in the predicted coefficients, computer inputs, and CTS positioning control. Maximum error in the CTS position control was  $\pm 0.05$  in. for the translational settings and  $\pm 0.15$  deg for angular displacement settings in pitch and yaw. Extrapolation tolerances were  $\pm 0.10$  for each of the aerodynamic coefficients. The maximum uncertainties in the full-scale position data caused by the balance precision limitations are given in Table II.

The estimated uncertainty in setting Mach number was no greater than  $\pm 0.003$ , and the uncertainty in parent-model angle of attack was estimated to be  $\pm 0.1$  deg.

## SECTION IV RESULTS AND DISCUSSION

### 4.1 GENERAL

All trajectories obtained were for use in the determination of safe-separation envelopes of the SUU-51/B from the F-4C aircraft. No attempt will be made in this report to establish these envelopes or to qualify the store as safe or unsafe for aircraft separation. The trajectory data are presented as obtained from the wind tunnel along with comments regarding the aerodynamics of the store in the aircraft flow field.

Data taken during this test consisted of ejector-separated trajectories simulating release from multiple carriage positions on the left and right wing inboard and centerline positions of the F-4C aircraft. Trajectories from the right wing were simulated by launching from the left wing with a reversed (1, 3, and 2) TER ejection sequence. Data showing the linear and angular displacements of the store relative to the mate position on the racks or pylons are presented as functions of full-scale trajectory time in Figs. 14 through 22. Positive X, Y, and Z displacements (as seen by the pilot) are forward, to the right (inboard), and down, respectively. Positive changes in pitch and yaw (as seen by the pilot) are nose up and nose right (inboard), respectively.

Open fin data were obtained for the SUU-51/B. The point of attachment of the 1.5-ft-long lanyard which deployed the fins is shown in Fig. 8. A listing of trajectories for which open fin data were obtained and the time in the trajectory at which the fins were deployed is given in Table III.

### 4.2 SUU-51/B TRAJECTORIES

Nine wing loading configurations of the SUU-51/B were tested. Most of the trajectories obtained were terminated because of CTS rig limitations before the model

fins could be deployed. Data are compared on the basis of aircraft dive angle. It can be seen that trajectories for a particular configuration at a particular test condition varied very little with aircraft dive angle. Generally, it can be seen that the store Z-displacement was greater for the simulated level flight than for the 30- and 45-deg dive angle trajectories because of the greater gravity-force component in level flight. For all configurations, the store exhibited initial negative pitch and yaw motions. At some test conditions the store yaw or pitch rate was so rapid that, in combination with small Z-displacement, the model contacted the TER or MER surface and stopped the trajectory after a very short time.

As seen by the data presented in Table III, only trajectories obtained at the lowest Mach numbers reached fin deployment distance. The data for these trajectories show that fin deployment resulted in both pitch and yaw recovery in the motion of the store.

**APPENDIXES**  
**I. ILLUSTRATIONS**  
**II. TABLES**



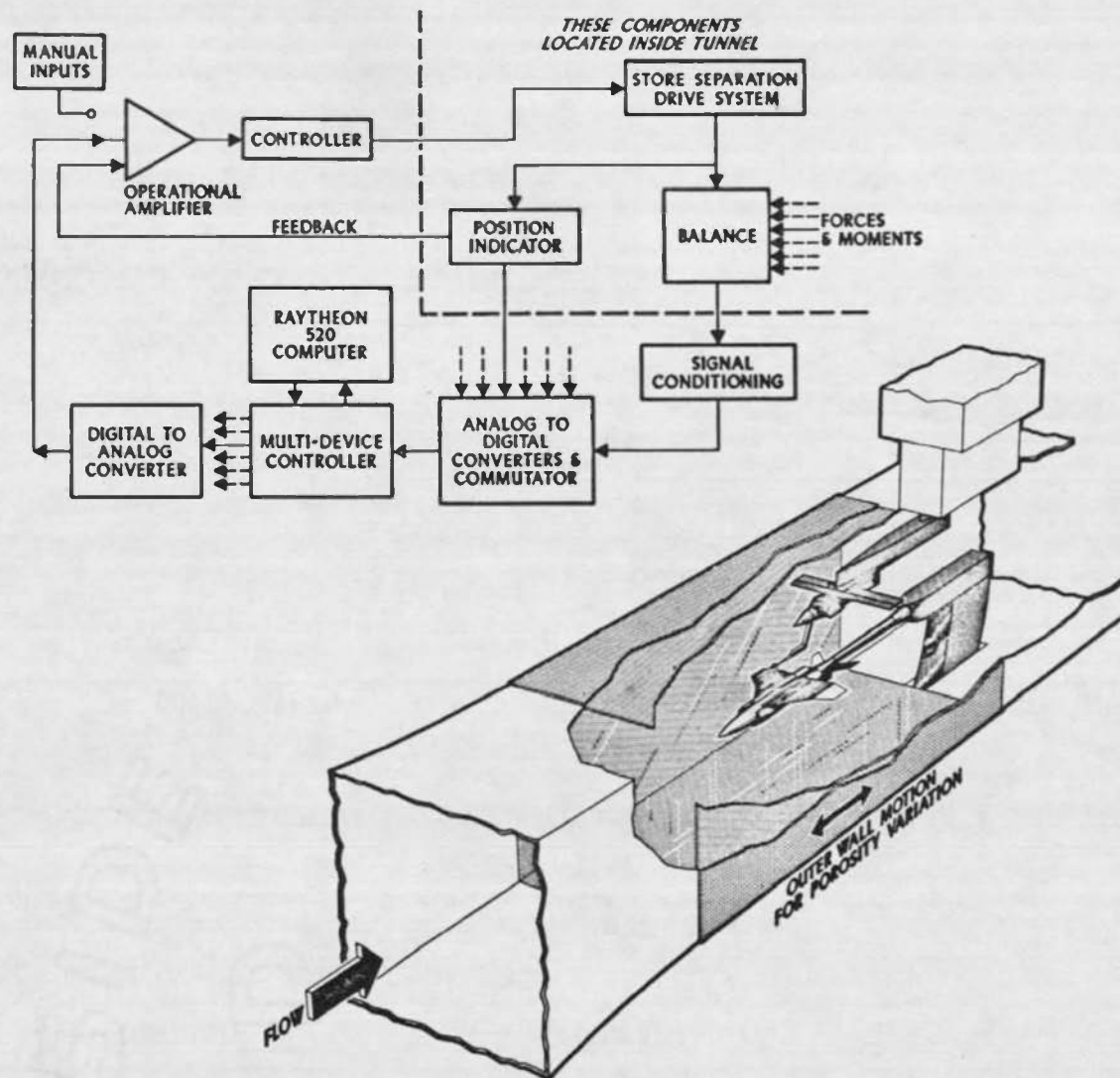
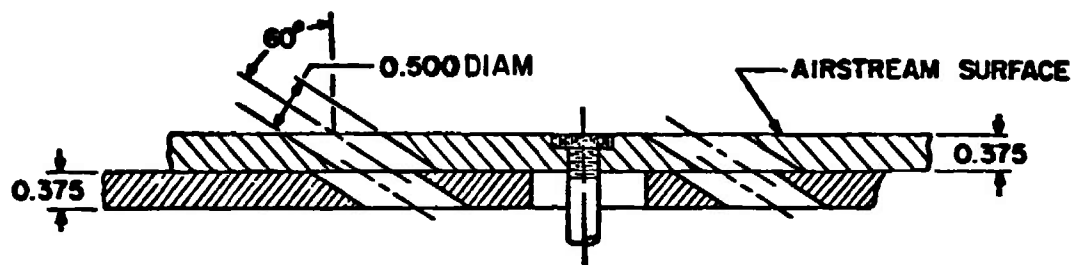


Fig. 1 Isometric Drawing of a Typical Store Separation Installation and a Block Diagram of the Computer Control Loop



TYPICAL PERFORATED WALL CROSS SECTION

NOTE: TUNNEL STATIONS AND DIMENSIONS ARE IN INCHES

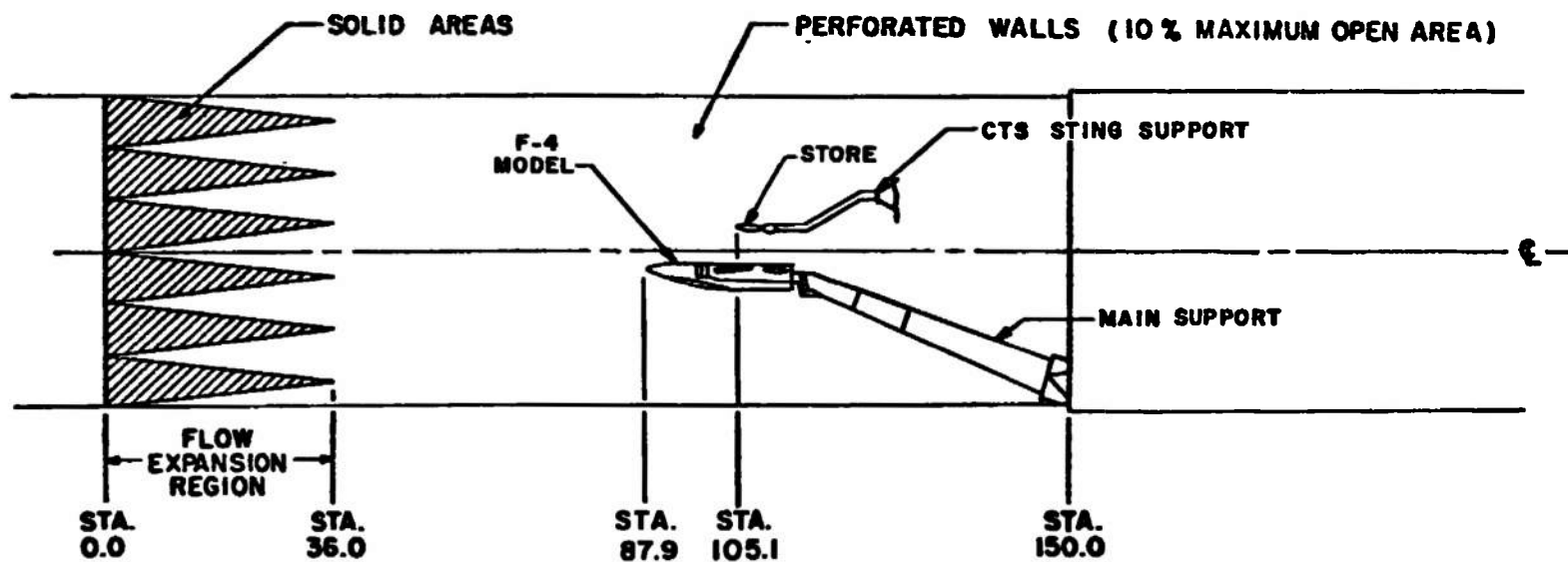


Fig. 2 Schematic of the Tunnel Test Section Showing Model Location

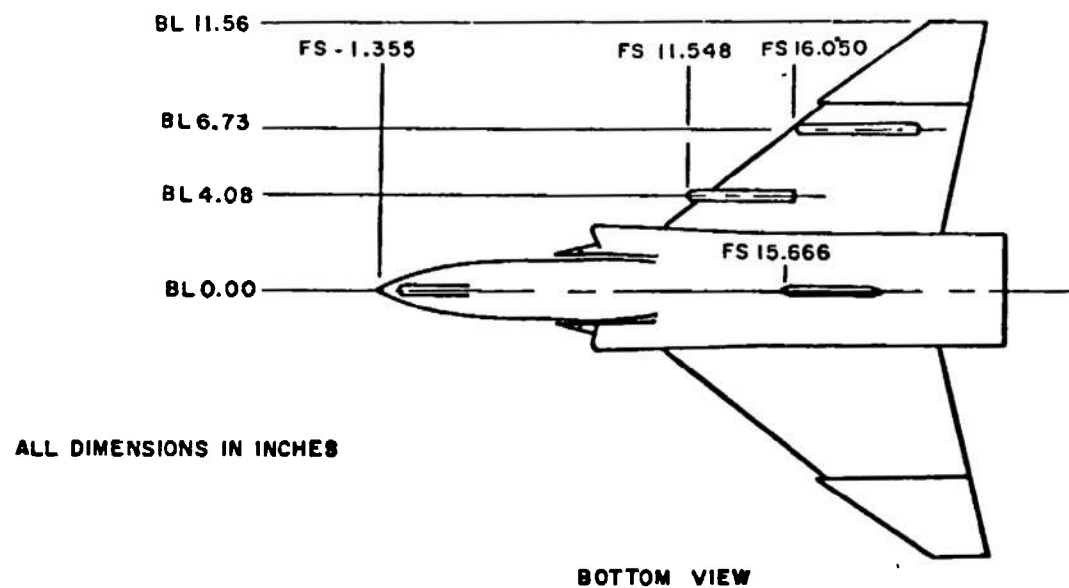
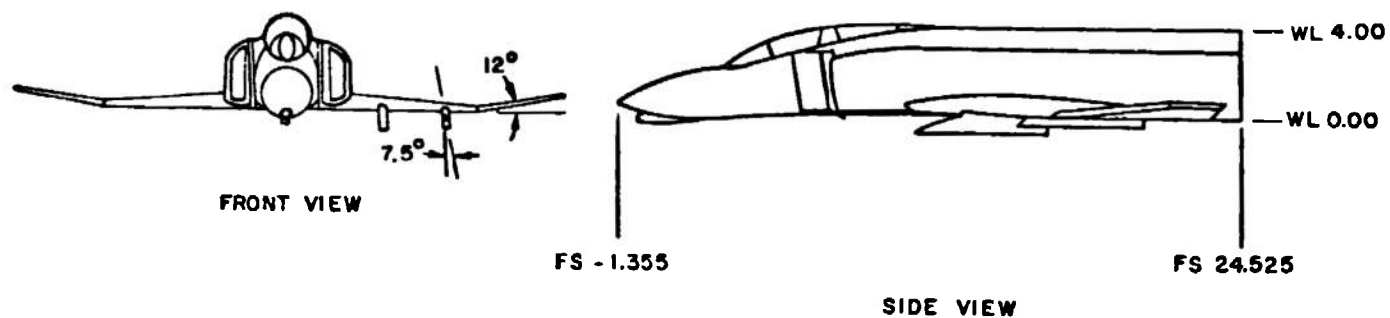


Fig. 3 Sketch of the F-4C Parent-Aircraft Model

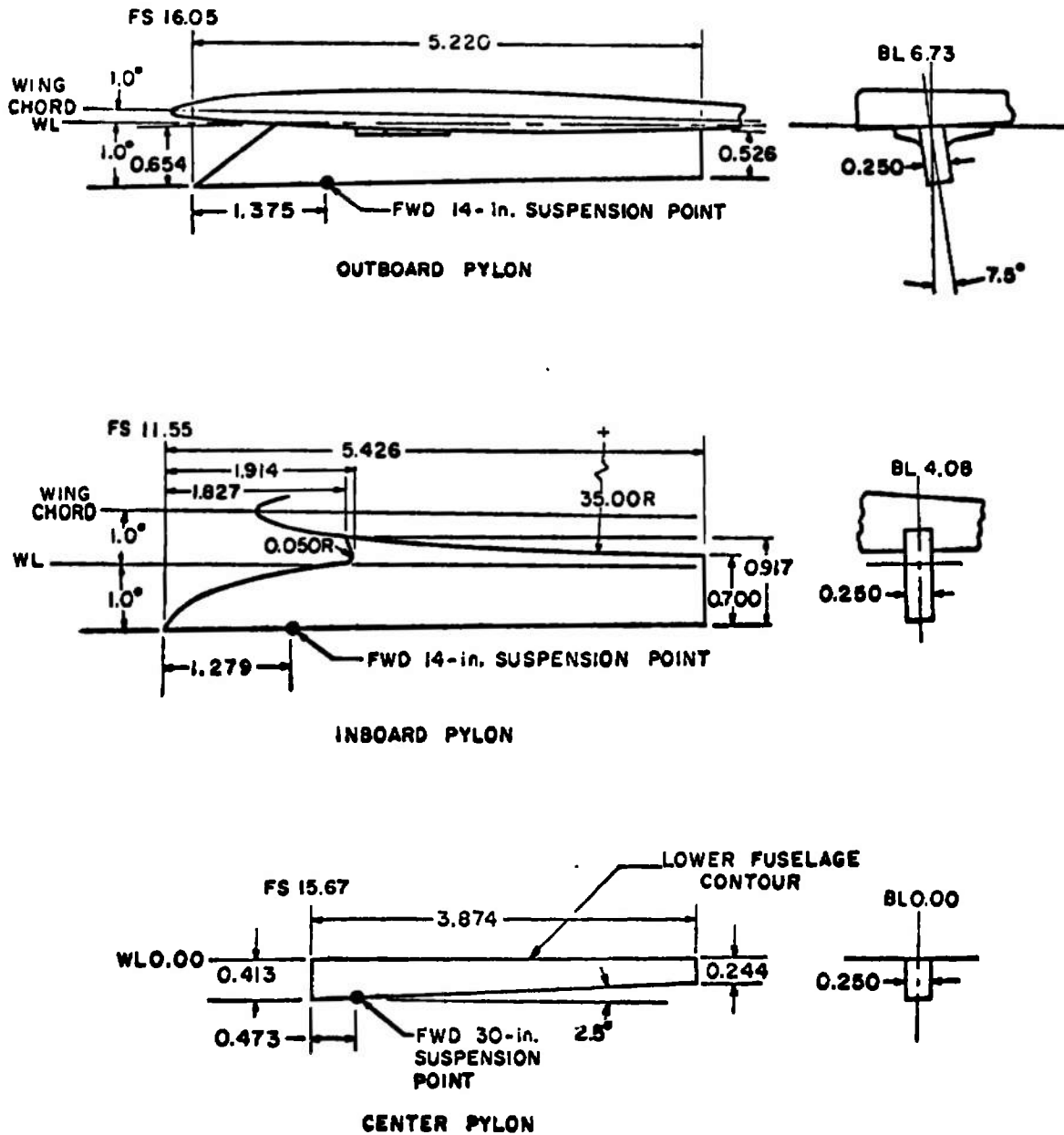


Fig. 4 Details and Dimensions of the F-4C Pylon Models

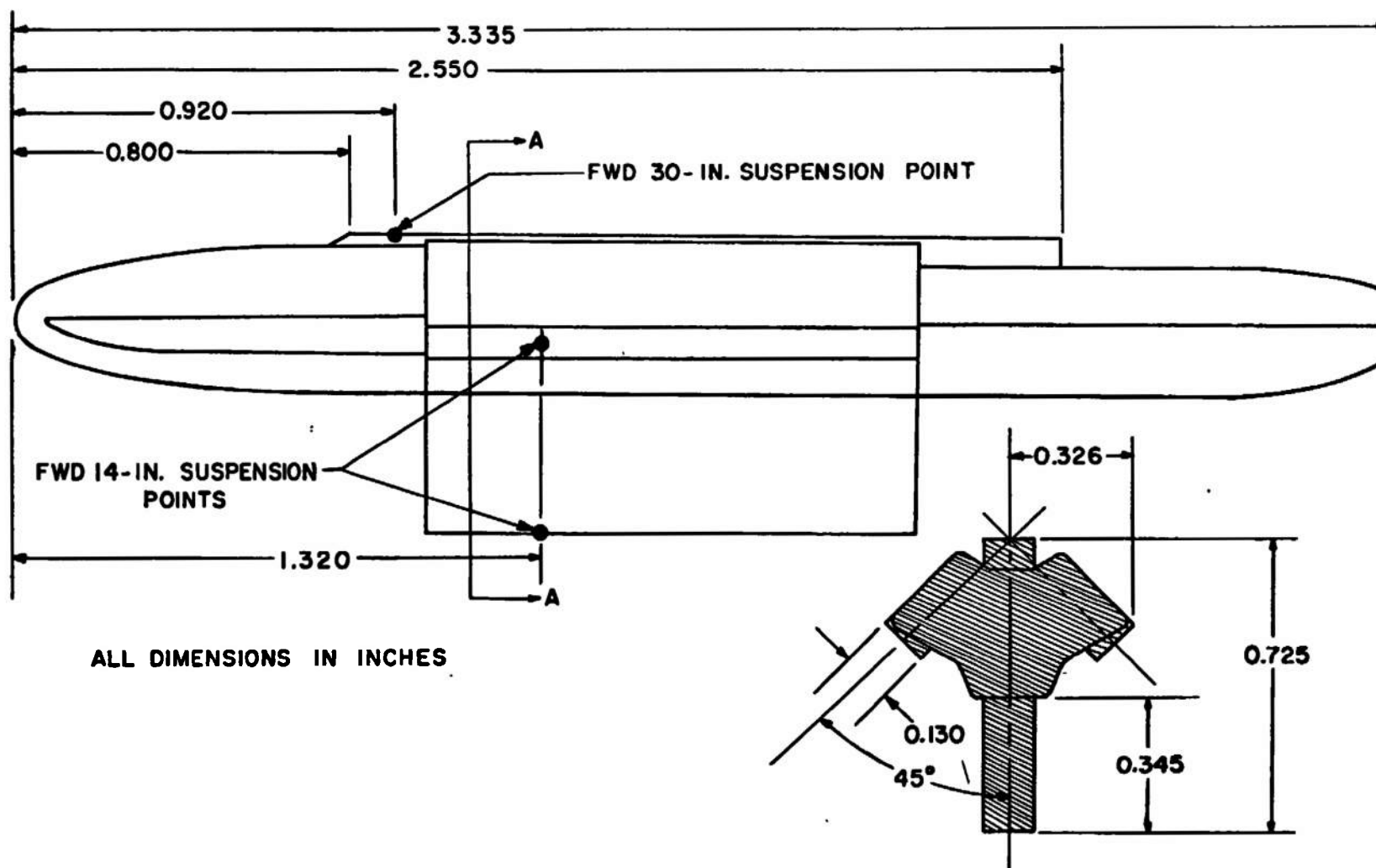


Fig. 5 Details and Dimensions of the TER Model

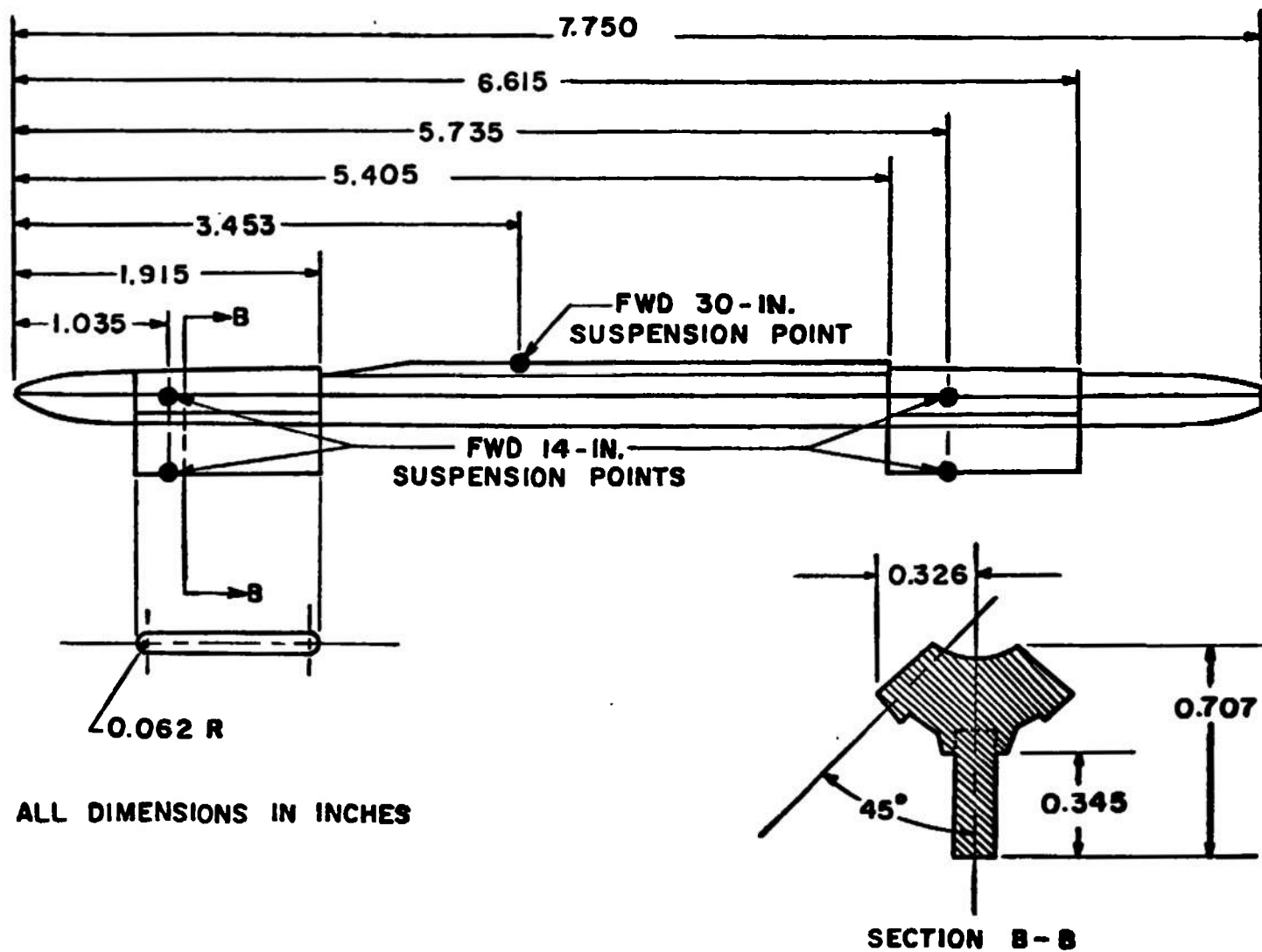


Fig. 6 Details and Dimensions of the MER Model

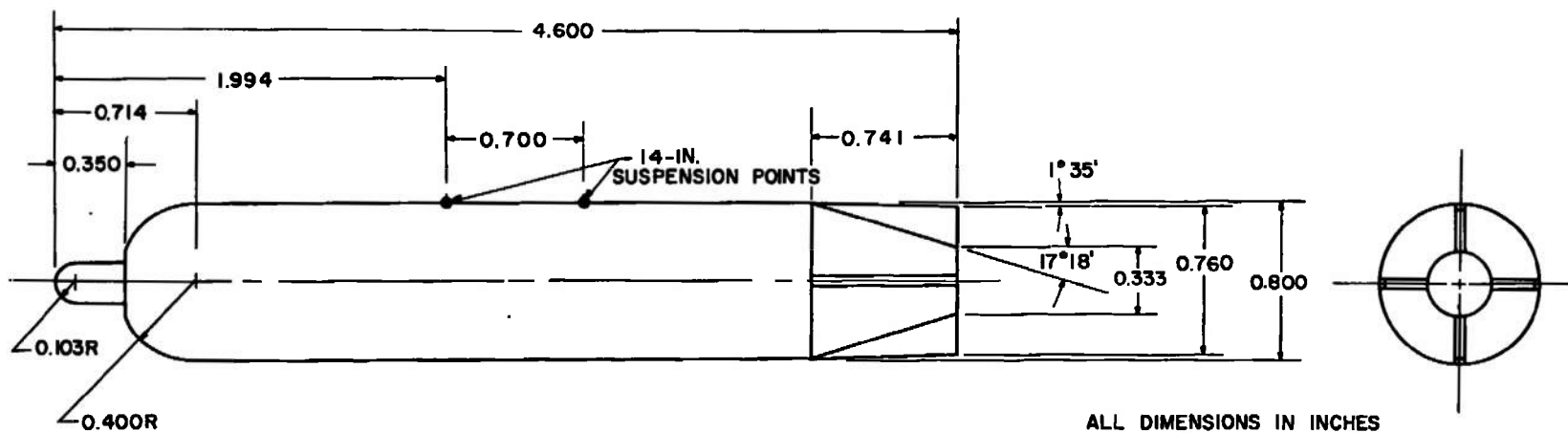


Fig. 7 Details and Dimensions of the Dummy SUU-51/B

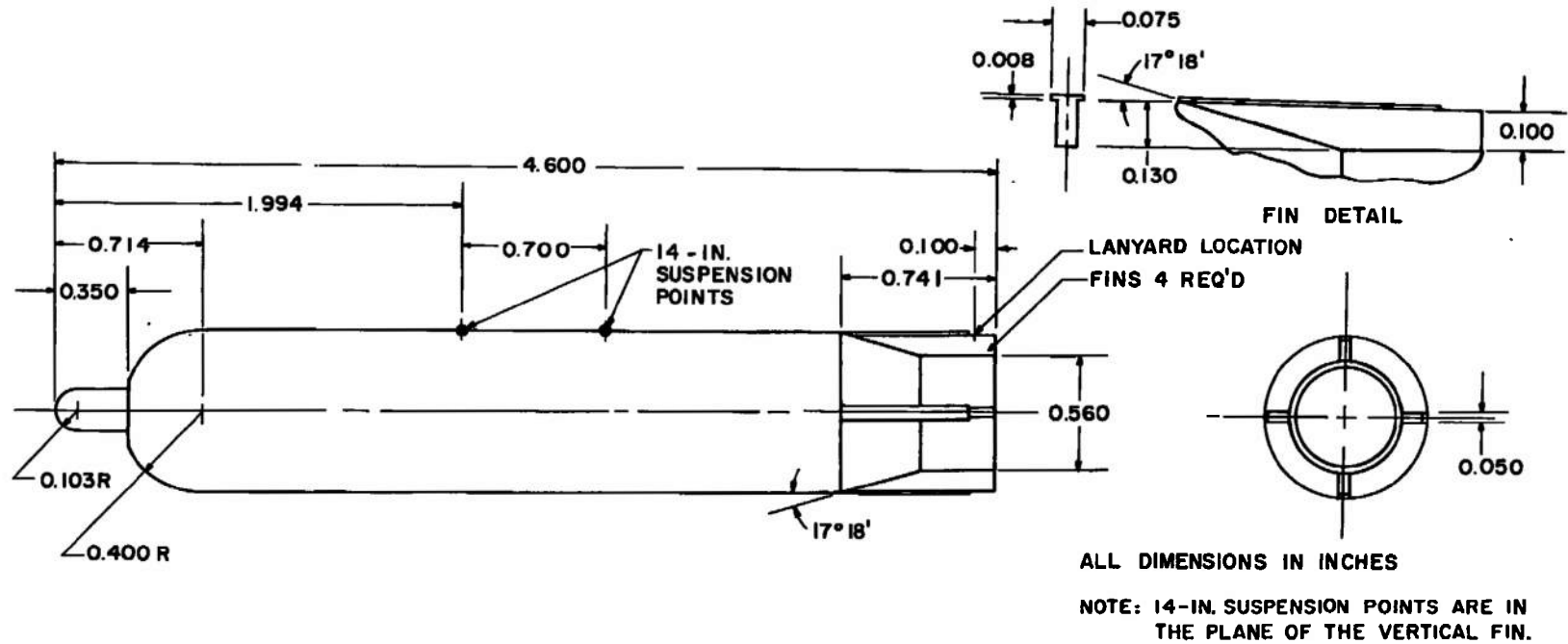


Fig. 8 Details and Dimensions of the Sting-Mounted SUU-51/B with Fins Folded



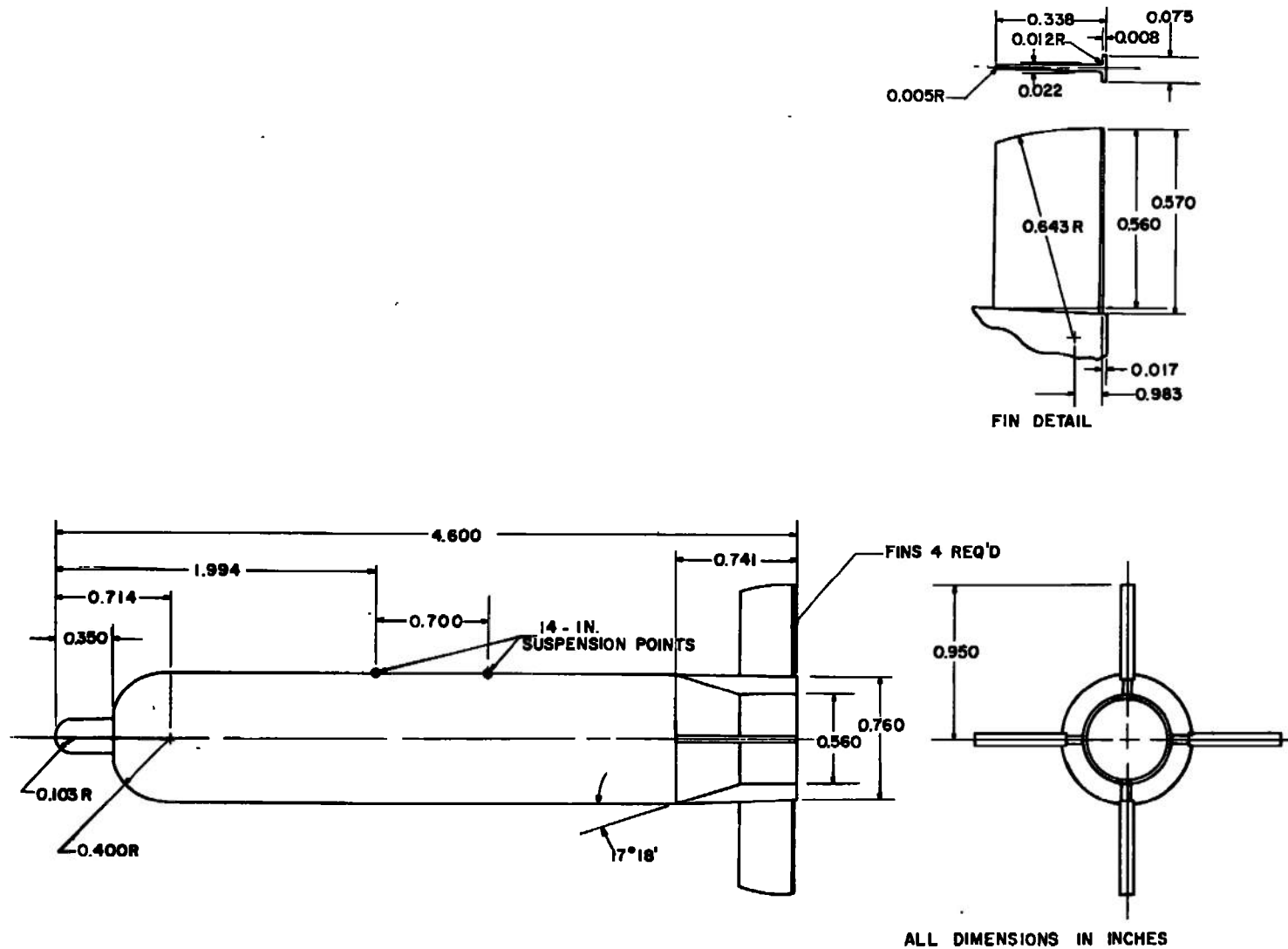
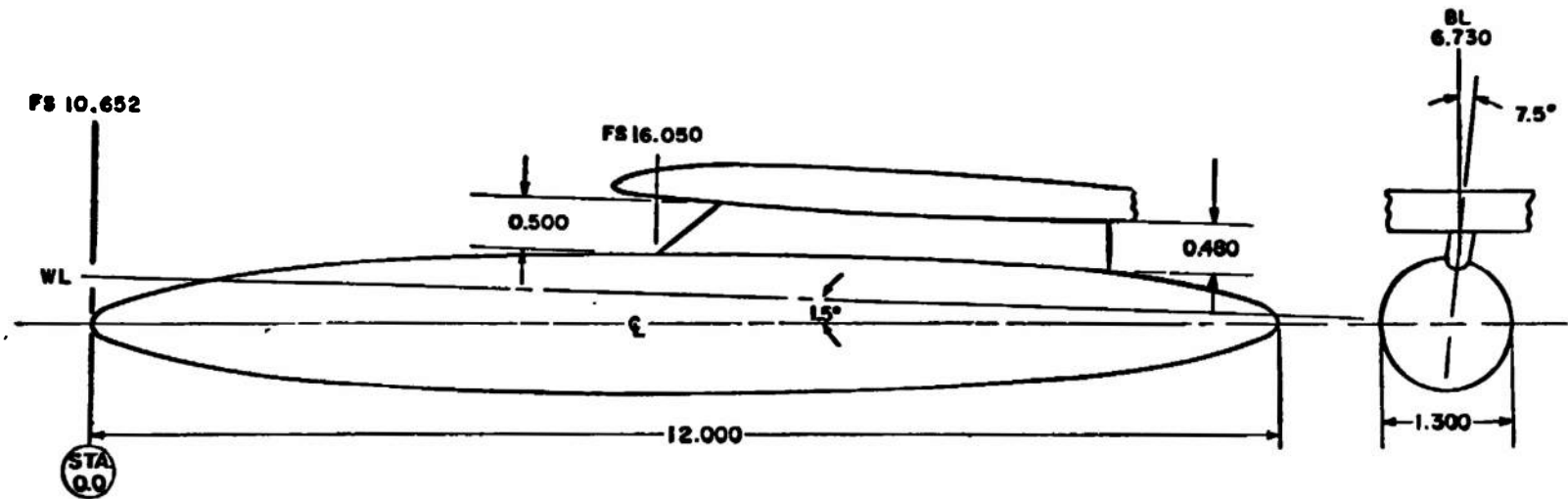


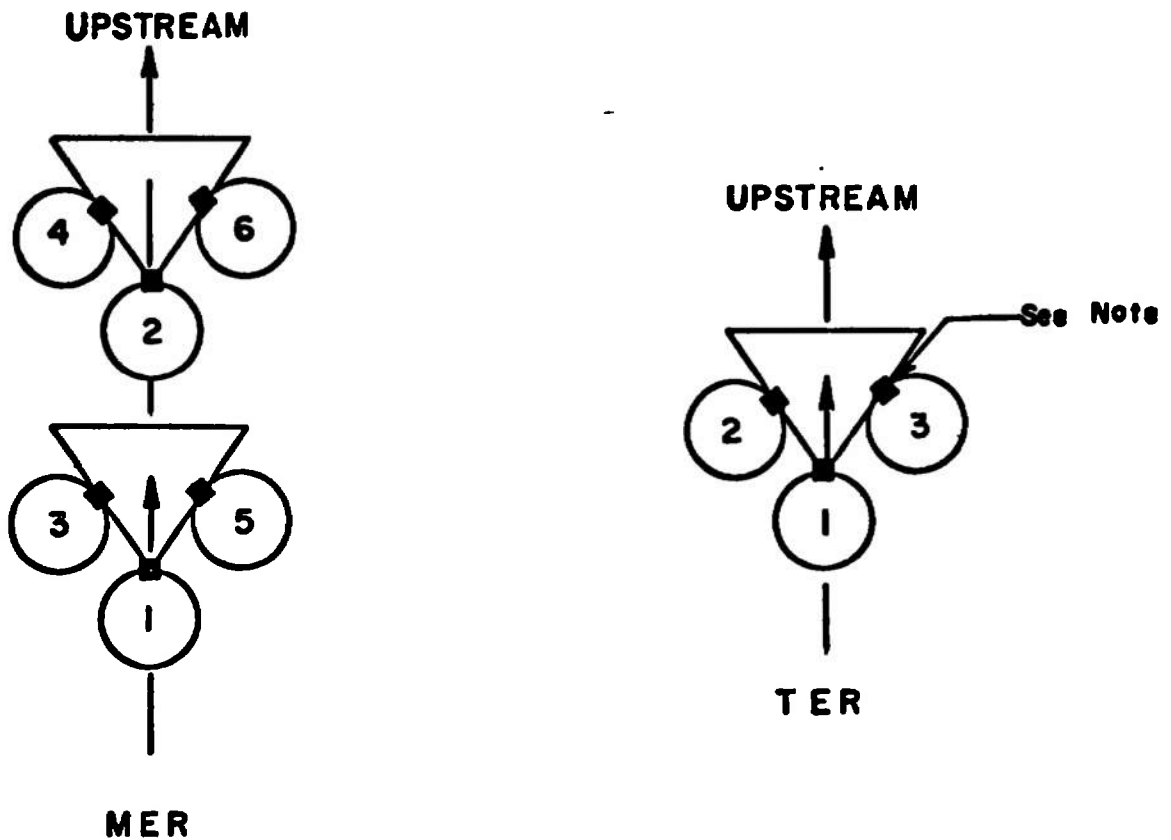
Fig. 9 Details and Dimensions of the Sting-Mounted SUU-51/B with Fins Deployed



ALL DIMENSIONS AND MODEL  
STATIONS IN INCHES

BODY CONTOUR, TYPICAL BOTH ENDS			
STATION	BODY DIAM	STATION	BODY DIAM
0.000	0.000	2.500	1.116
0.025	0.100	2.750	1.156
0.050	0.144	3.000	1.190
0.150	0.258	3.250	1.218
0.250	0.340	3.500	1.242
0.500	0.498	3.750	1.260
0.750	0.622	4.000	1.274
1.000	0.724	4.250	1.286
1.250	0.812	4.500	1.294
1.500	0.890	4.750	1.298
1.750	0.958	5.000	1.300
2.000	1.016	6.000	1.300
2.250	1.070		

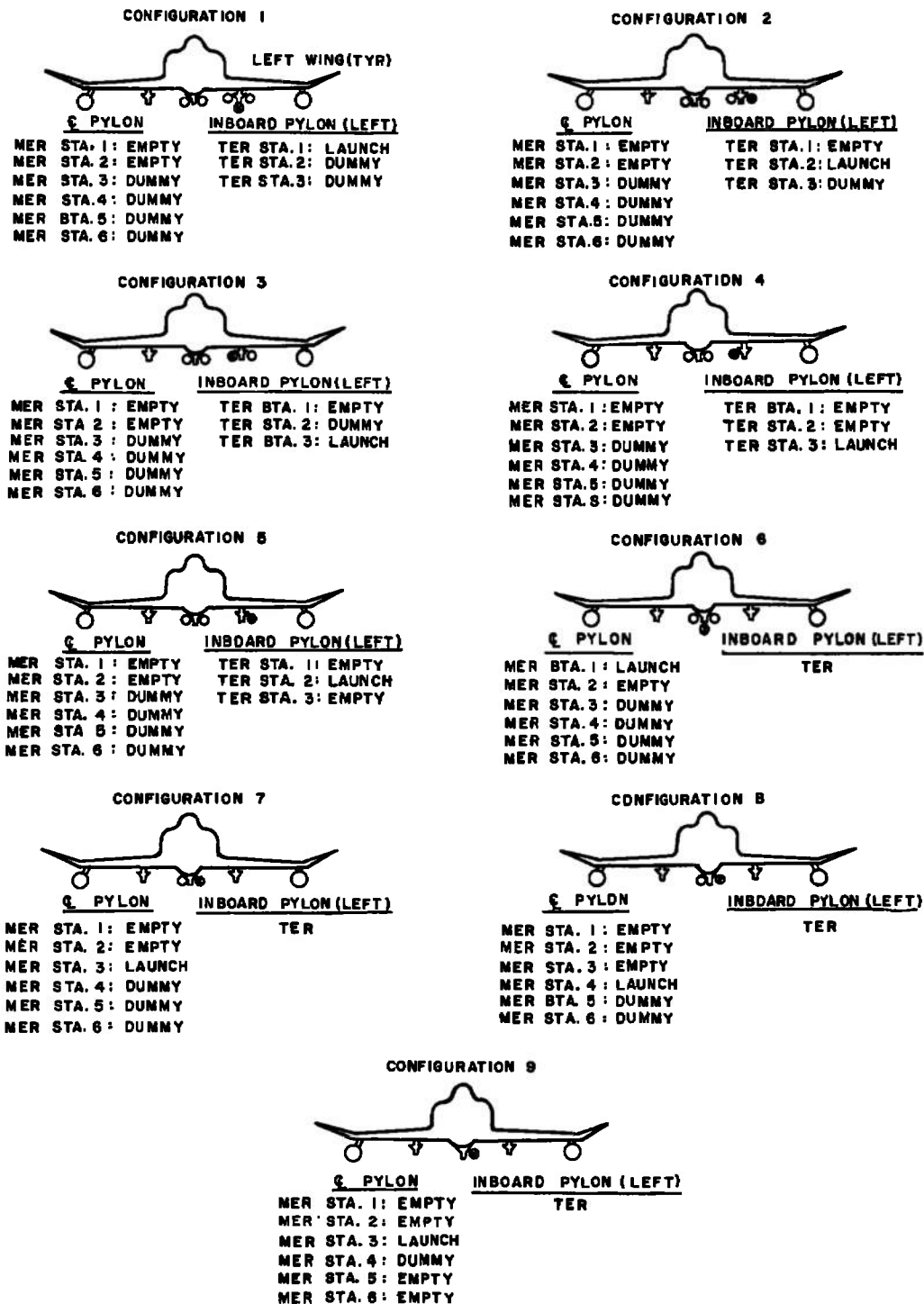
Fig. 10 Details and Dimensions of the Dummy 370-gal Fuel Tank



**NOTE:** The square indicates the orientation of the suspension lugs

TYPE RACK	STATION	ROLL ORIENTATION, deg
<b>MER</b> ↓	1	0
	2	0
	3	45
	4	45
	5	-45
	6	-45
<b>TER</b> ↓	1	0
	2	45
	3	-45

Fig. 11 Schematic of the TER and MER Store Stations and Orientation



NOTE: EMPTY TER ON RIGHT INBOARD PYLON  
AND 370 GALLON FUEL TANKS ON OUTBOARD  
PYLONS FOR ALL CONFIGURATIONS TESTED

Fig. 12 F-4C Load Configurations

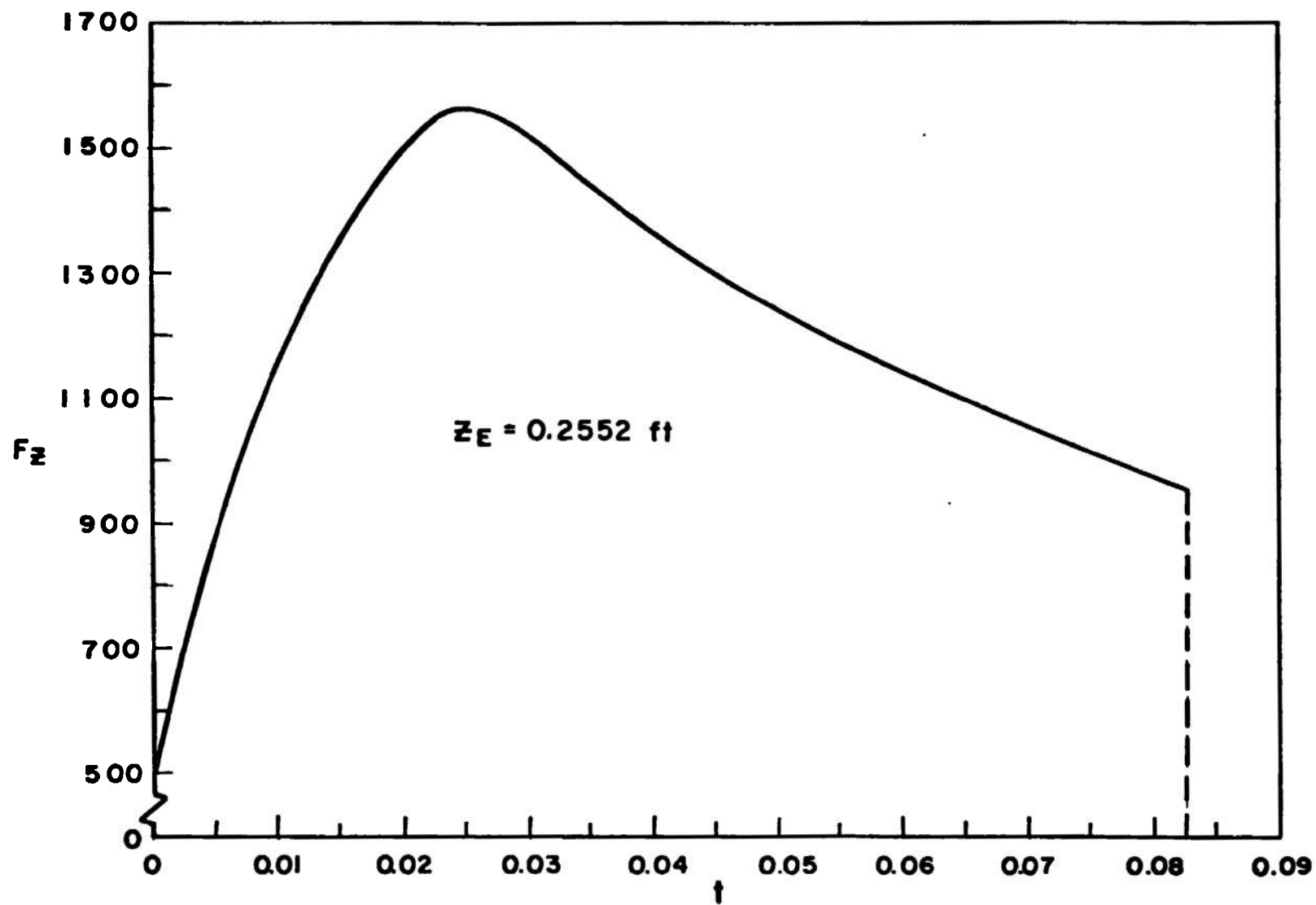
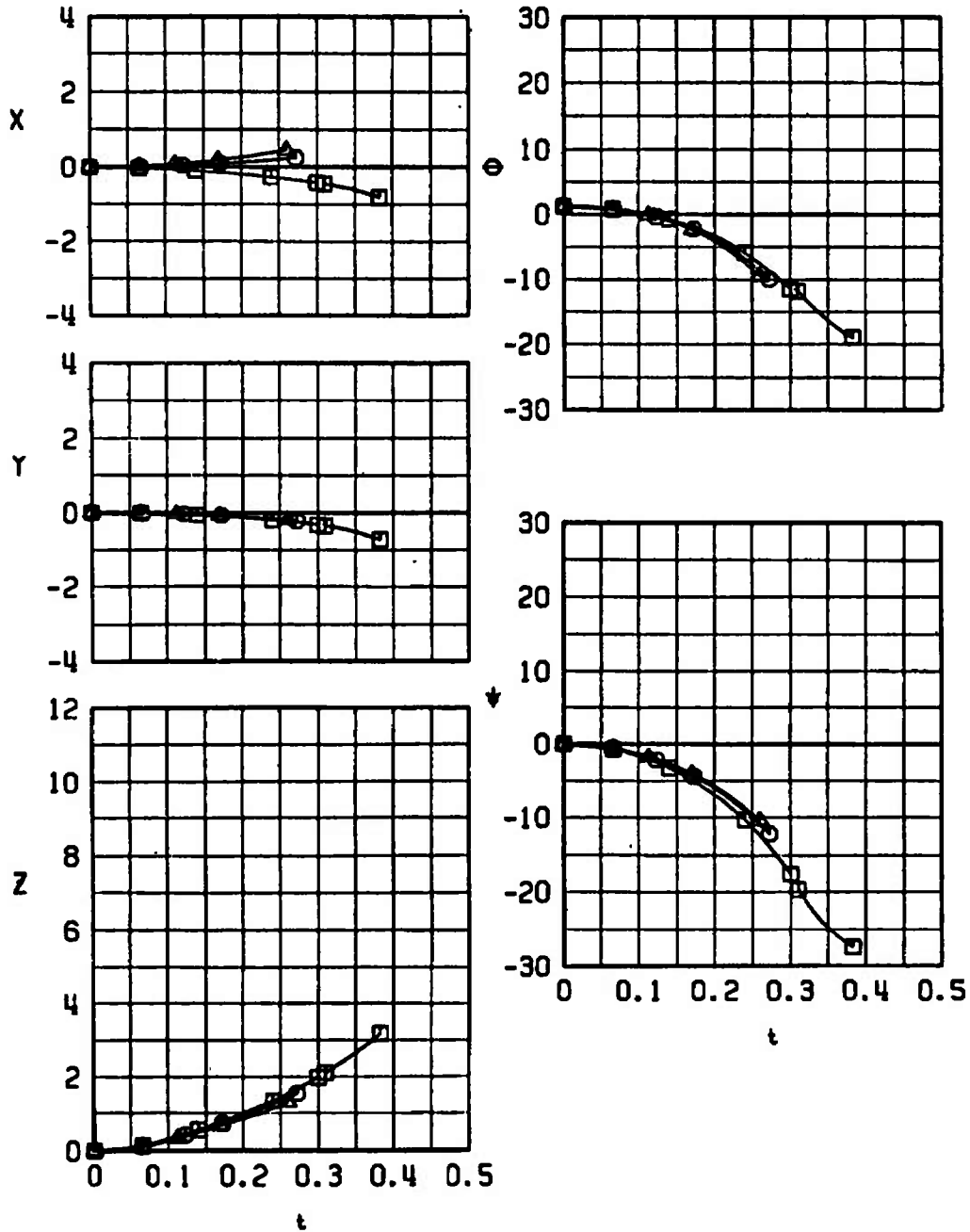


Fig. 13 TER and MER Ejector Force Function

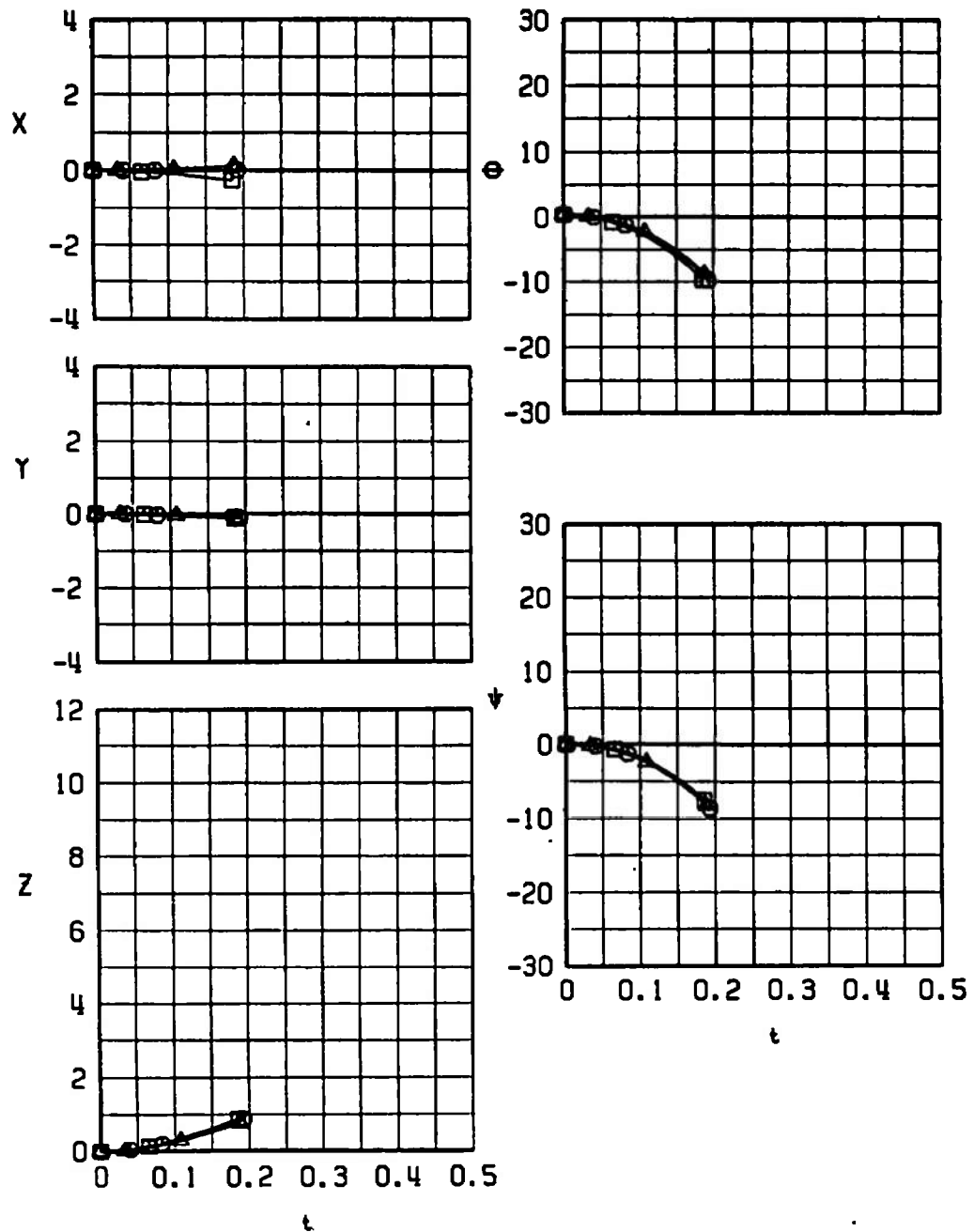
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	1	0.66	2.2	0
○	1	0.66	2.2	-30
△	1	0.66	2.2	-45



a.  $M_\infty = 0.66$

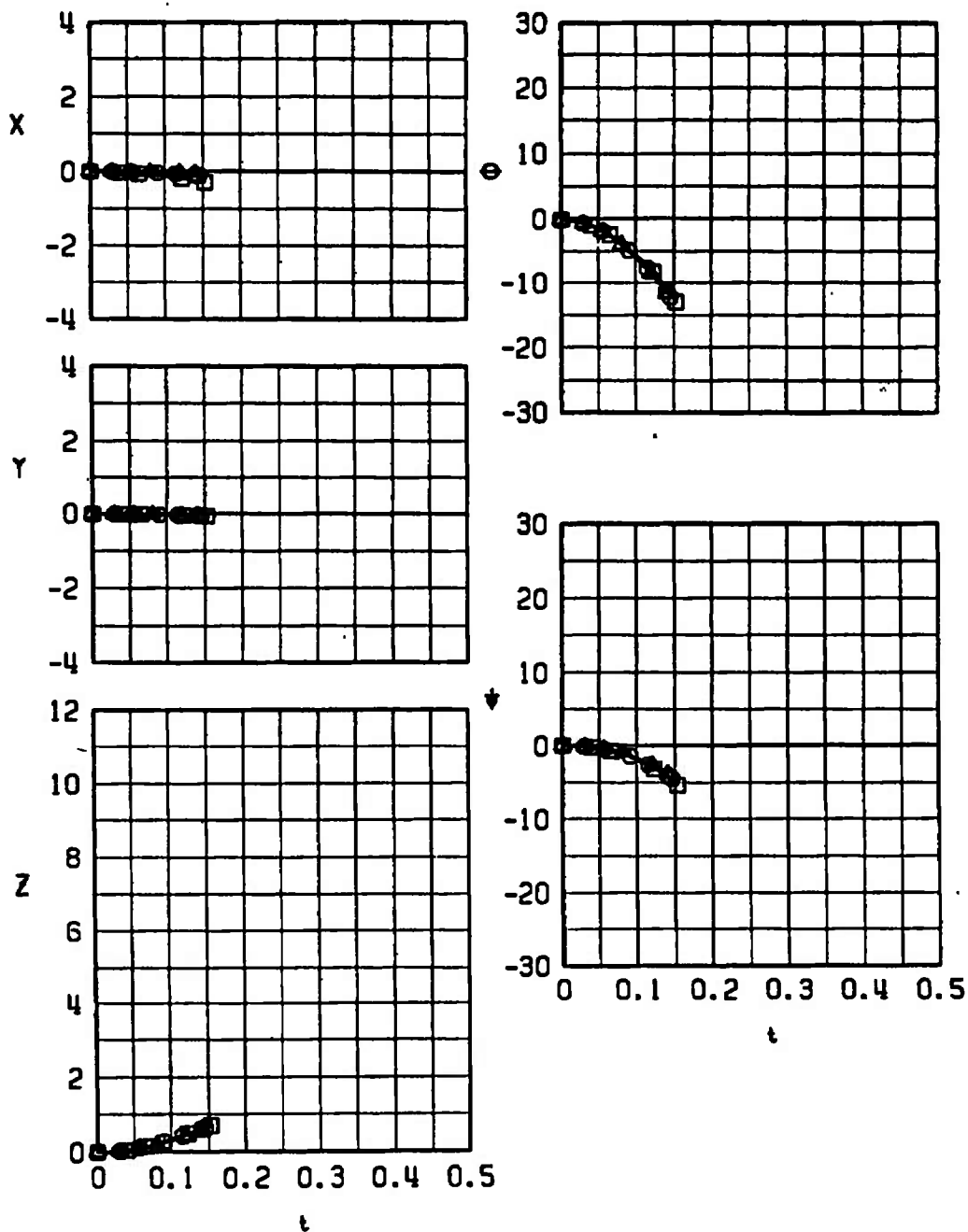
Fig. 14 Separation Trajectory Data for Configuration 1

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	1	0.74	1.4	0
○	1	0.74	1.4	-30
△	1	0.74	1.4	-45



b.  $M_\infty = 0.74$   
Fig. 14 Continued

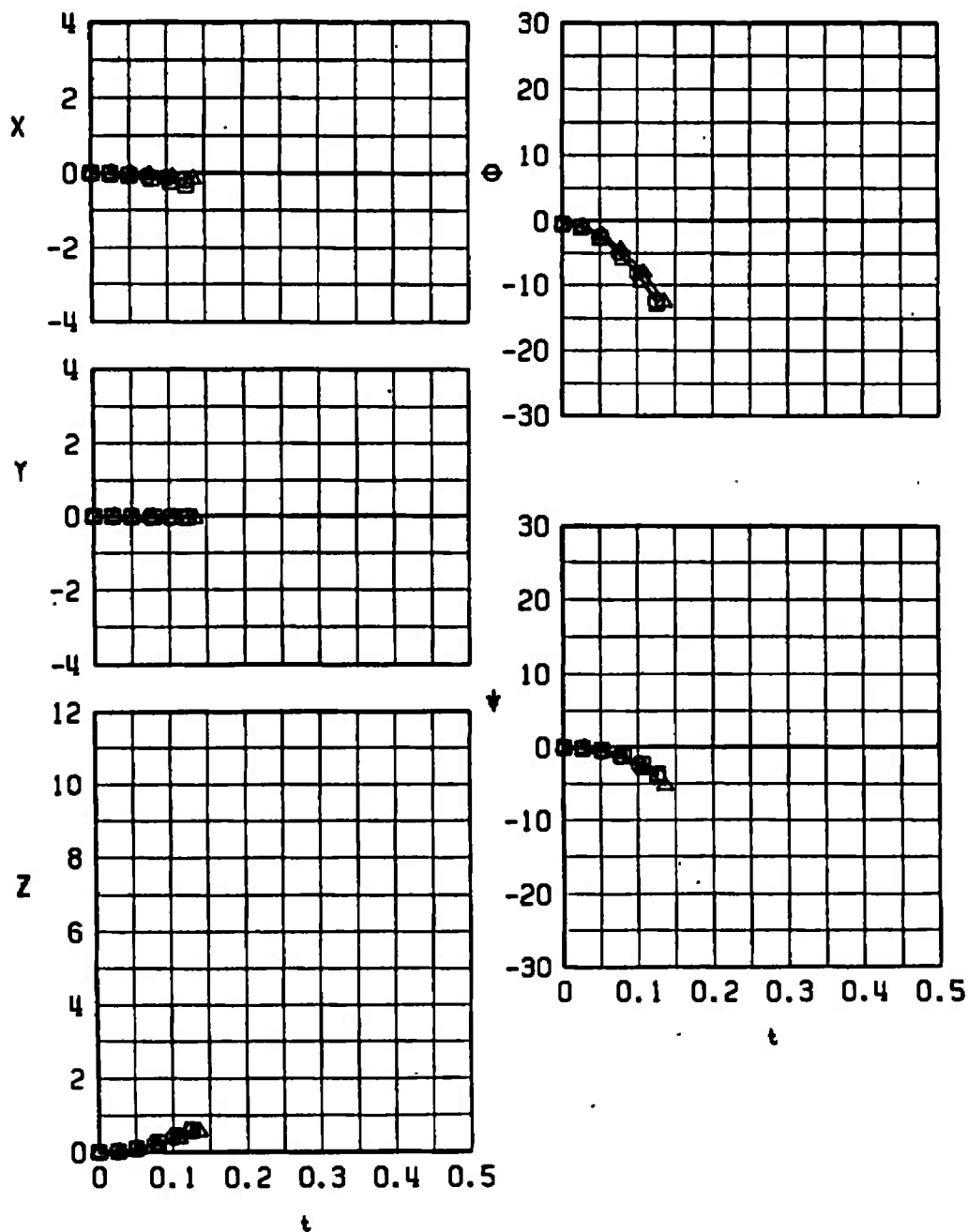
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	1	0.82	0.8	0
○	1	0.82	0.8	-30
△	1	0.82	0.8	-45



c.  $M_\infty = 0.80$   
Fig. 14 Continued



SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	1	0.90	0.5	0
○	1	0.90	0.5	-30
△	1	0.90	0.5	-45



d.  $M_\infty = 0.90$   
Fig. 14 Concluded

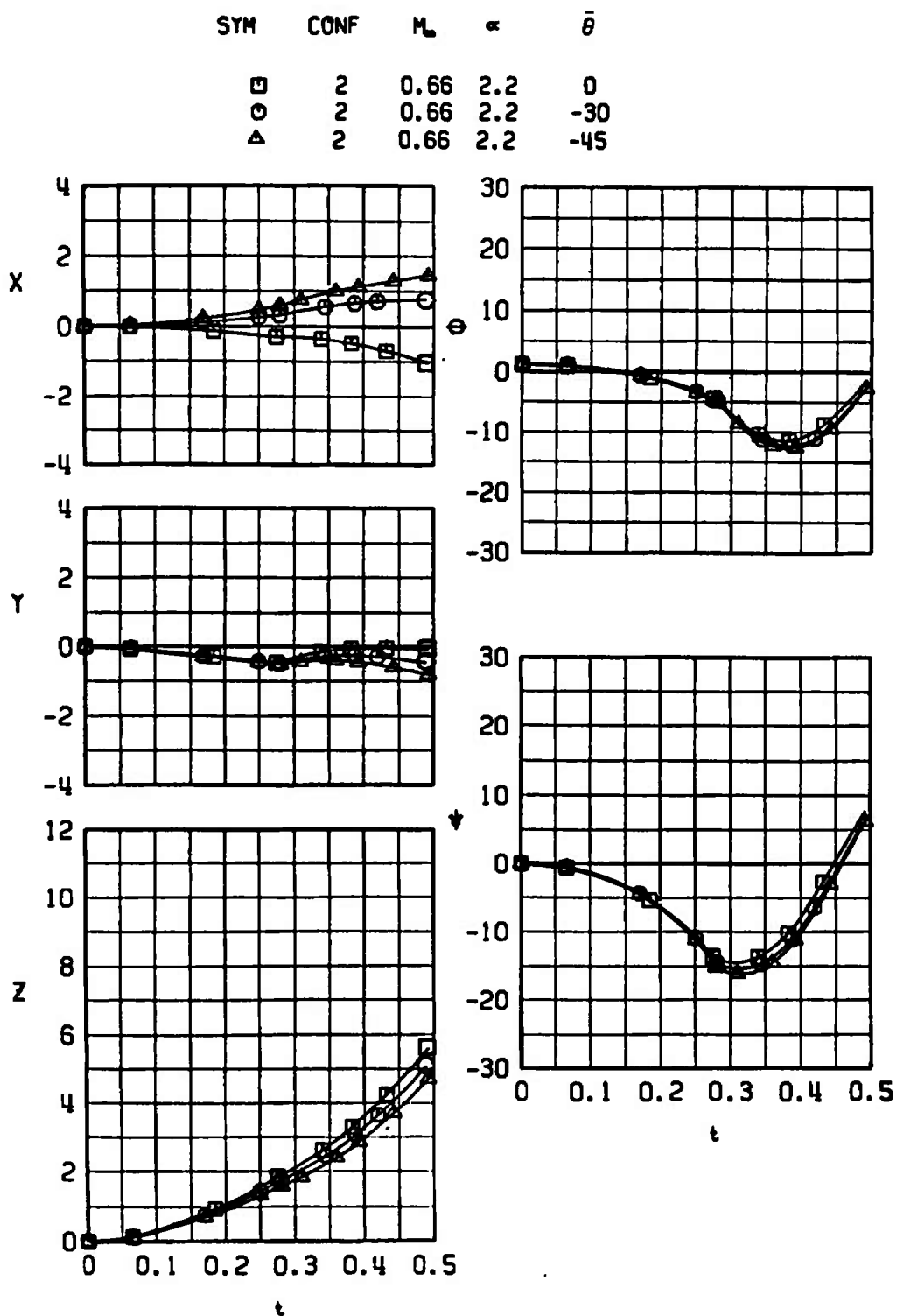
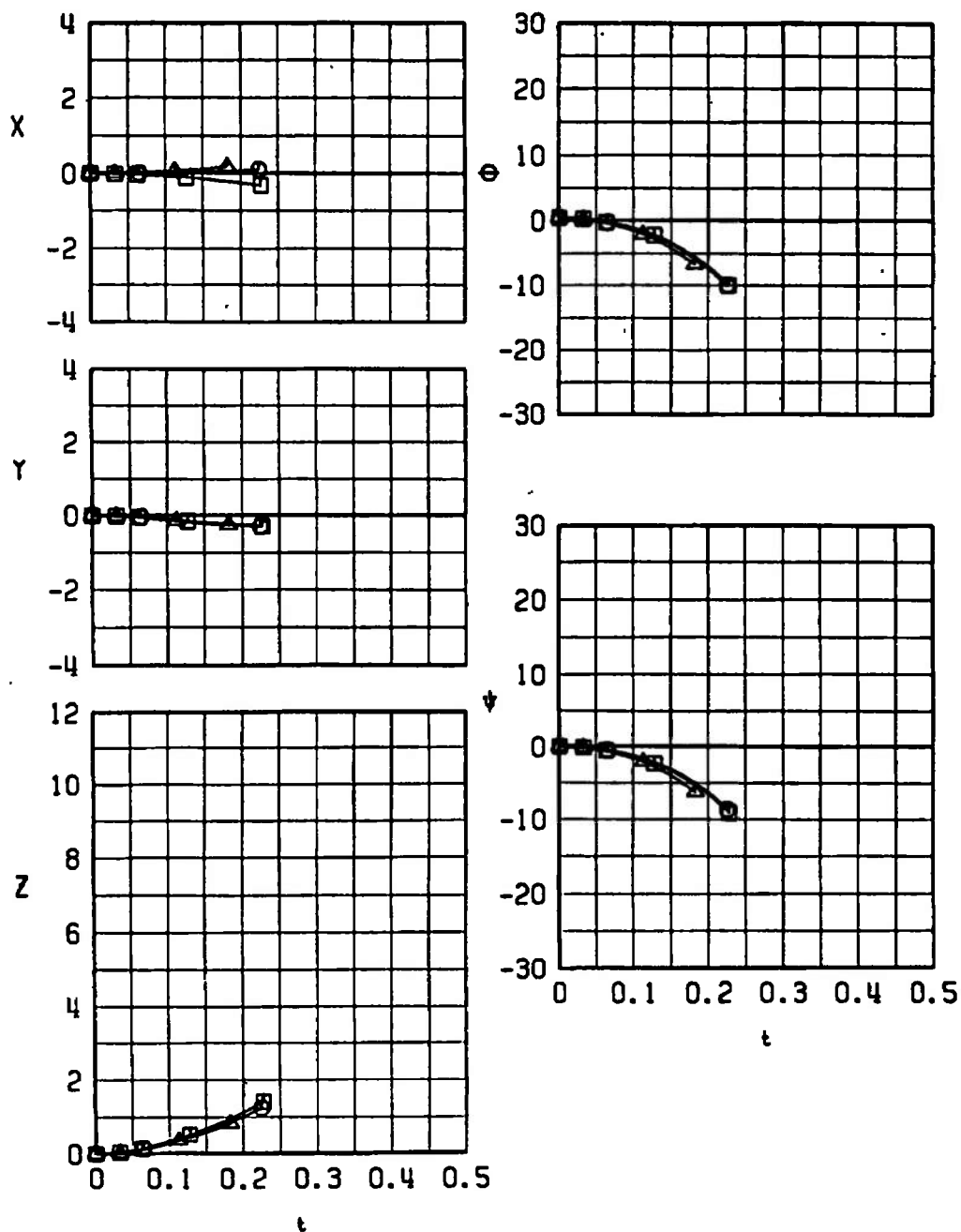
a.  $M_\infty = 0.66$ 

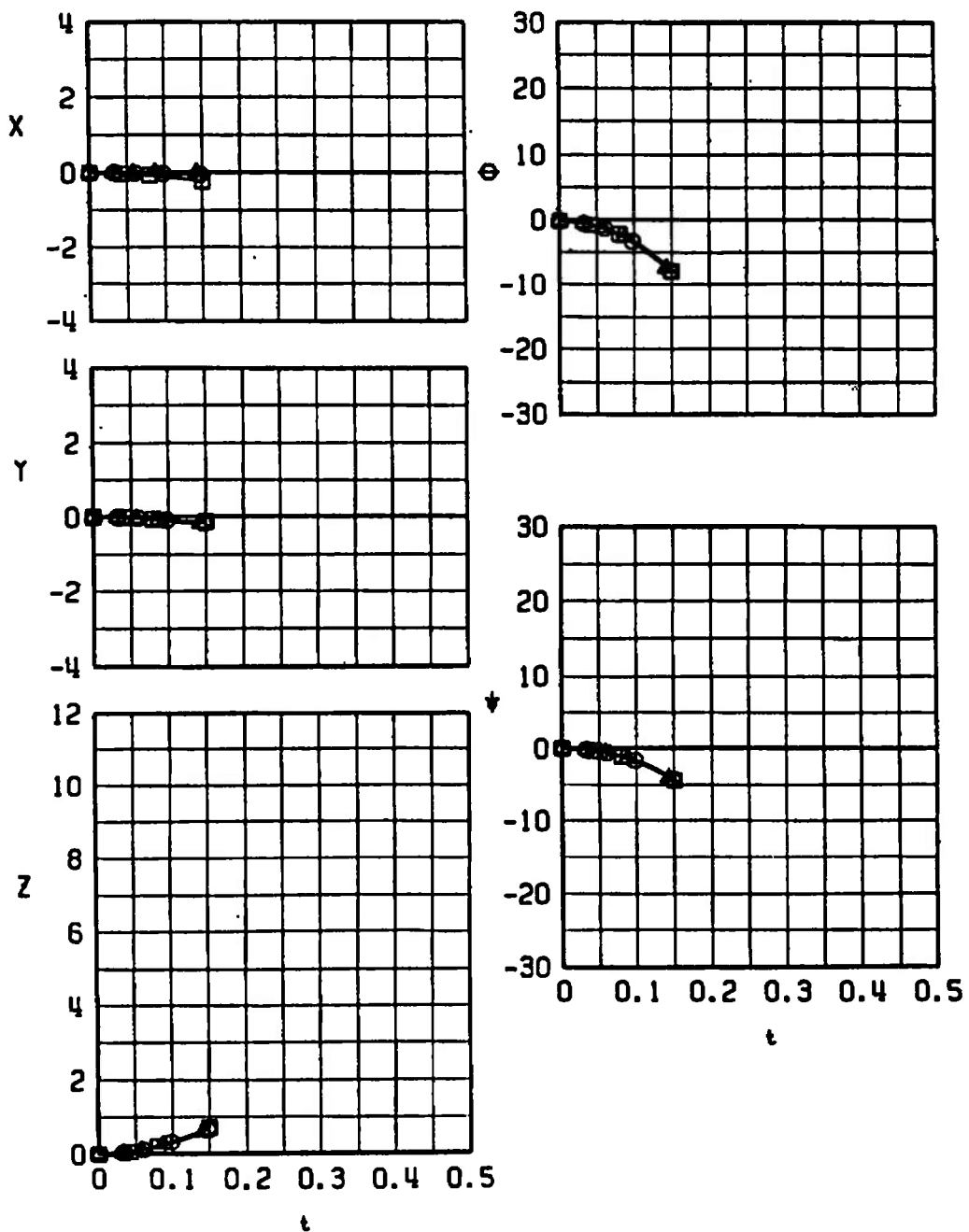
Fig. 15 Separation Trajectory Data for Configuration 2

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	2	0.74	1.4	0
○	2	0.74	1.4	-30
△	2	0.74	1.4	-45



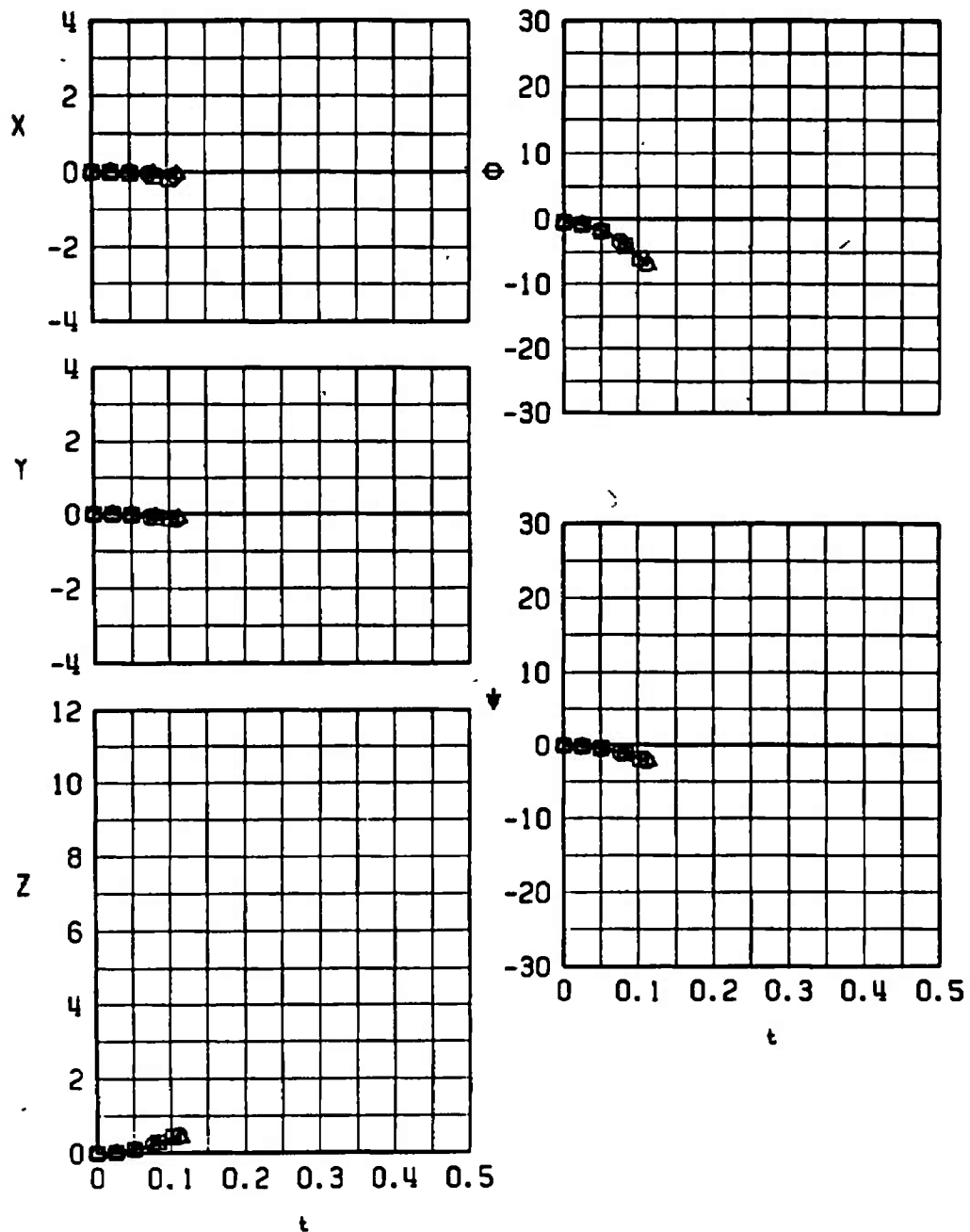
b.  $M_\infty = 0.74$   
Fig. 15 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	2	0.82	0.8	0
○	2	0.82	0.8	-30
△	2	0.82	0.8	-45



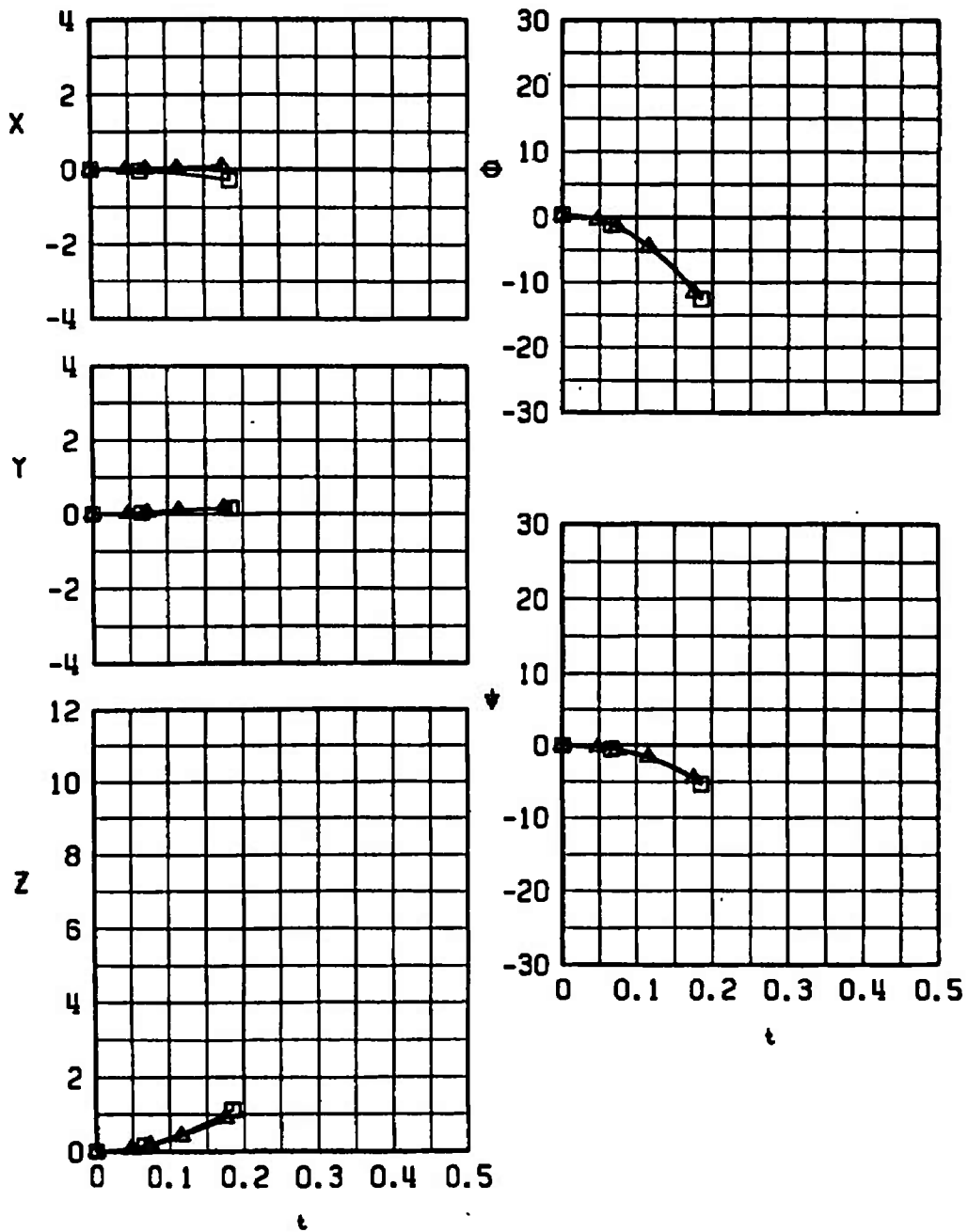
c.  $M_\infty = 0.82$   
Fig. 15 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	2	0.90	0.5	0
○	2	0.90	0.5	-30
△	2	0.90	0.5	-45



d.  $M_\infty = 0.90$   
Fig. 15 Concluded

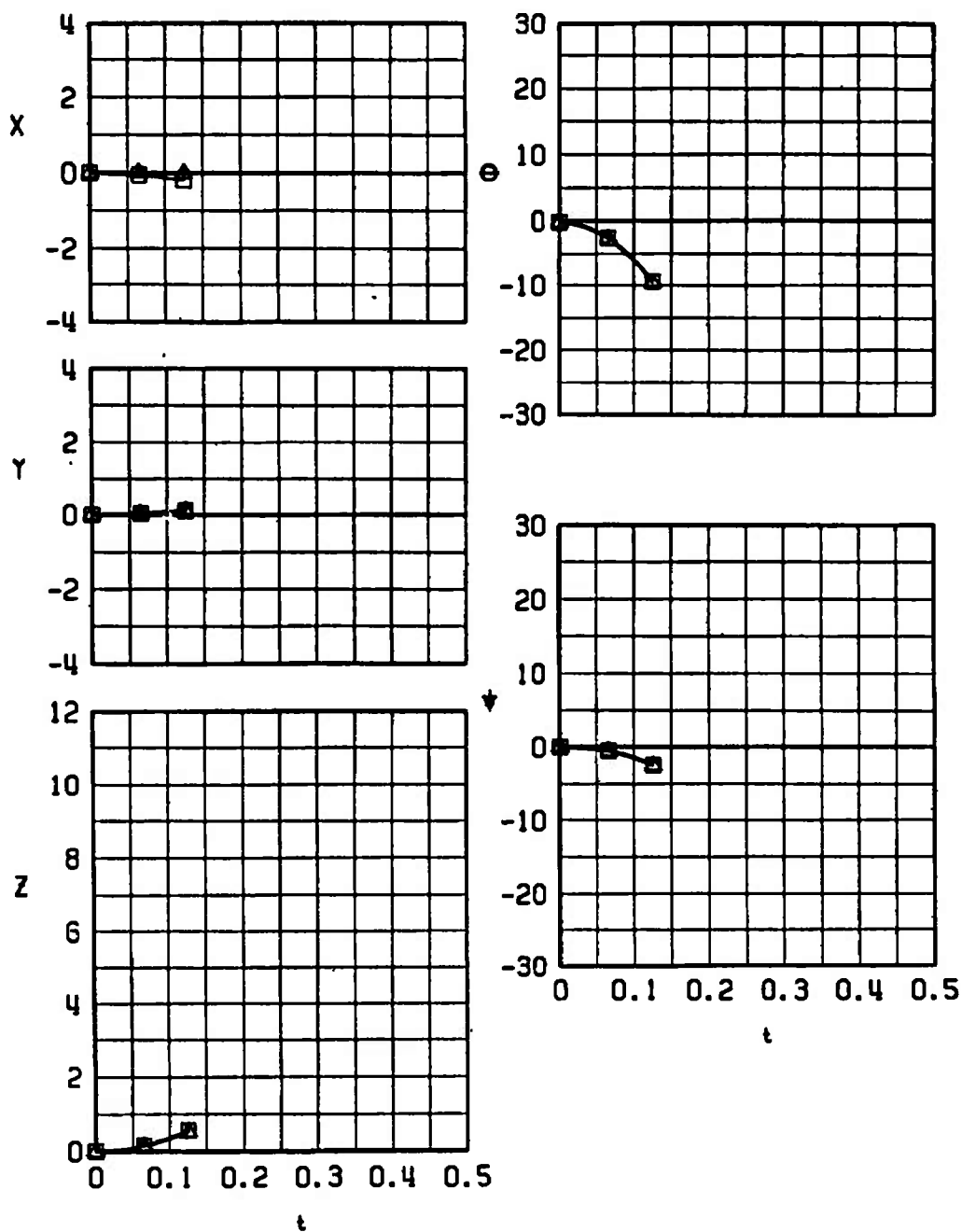
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	3	0.74	1.4	0
△	3	0.74	1.4	-45



a.  $M_\infty = 0.74$

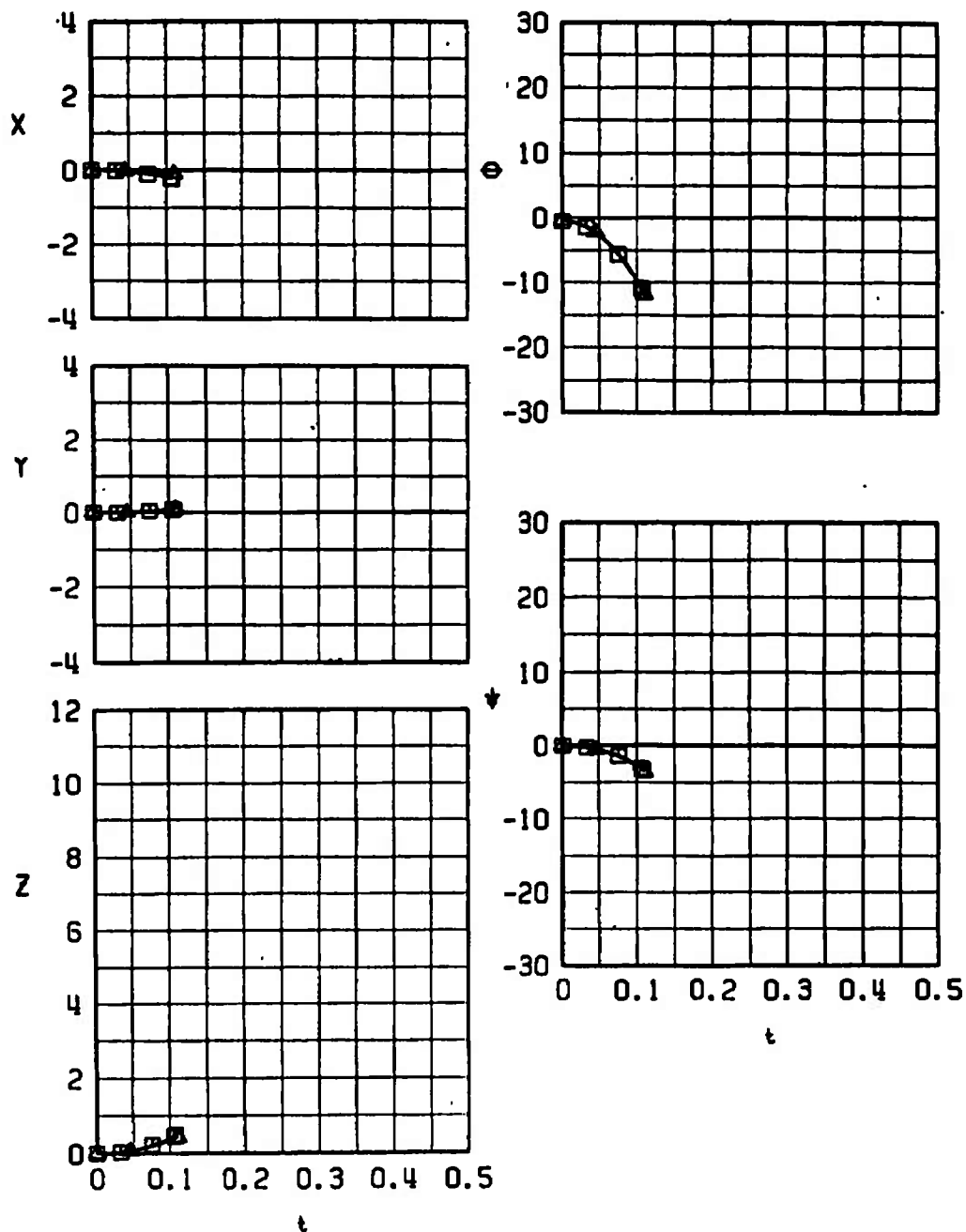
Fig. 16 Separation Trajectory Data for Configuration 3

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	3	0.82	0.8	0
△	3	0.82	0.8	-45



b.  $M_\infty = 0.82$   
Fig. 16 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	3	0.90	0.5	0
△	3	0.90	0.5	-45



c.  $M_\infty = 0.90$   
Fig. 16 Concluded



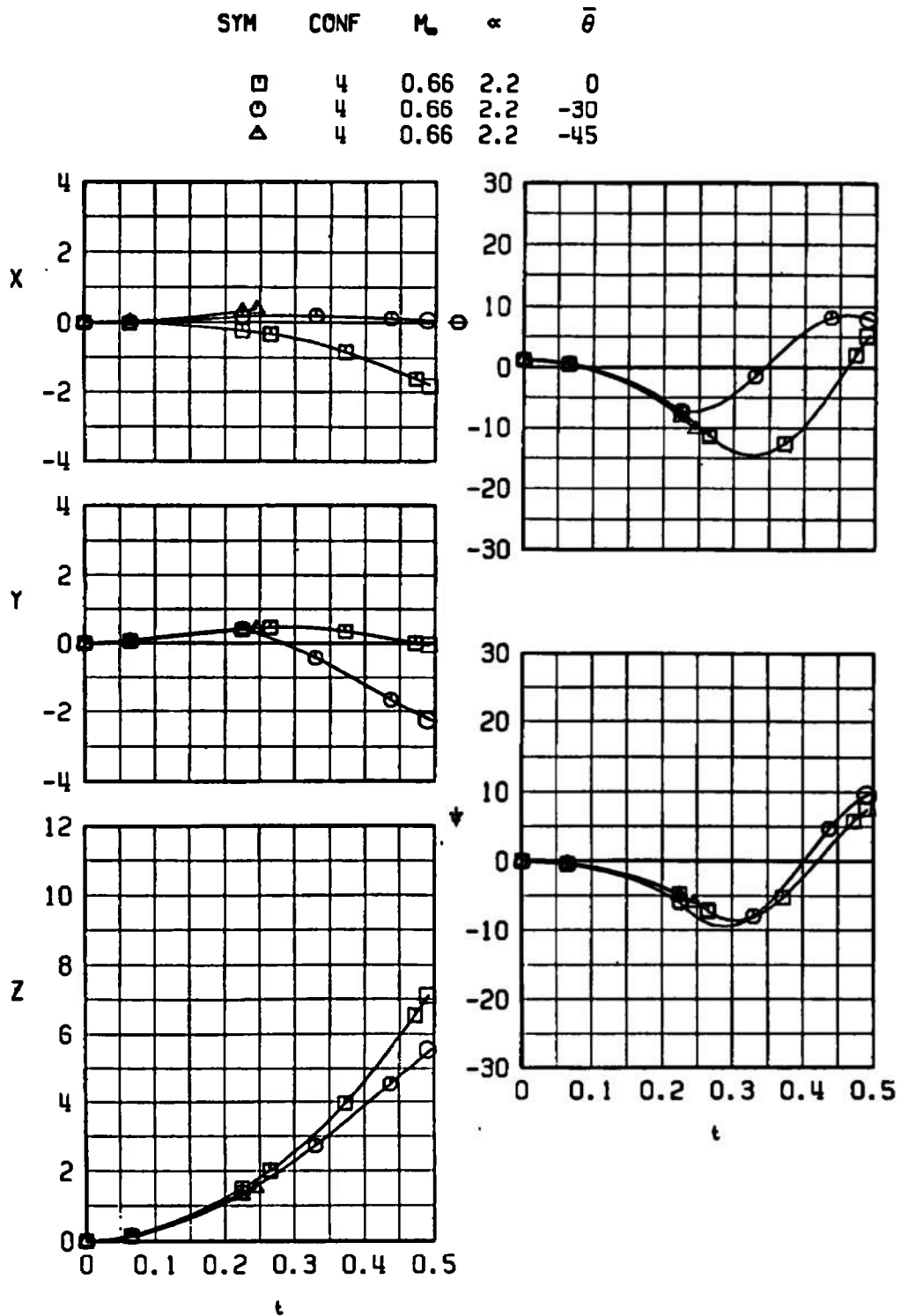


Fig. 17 Separation Trajectory Data for Configuration 4

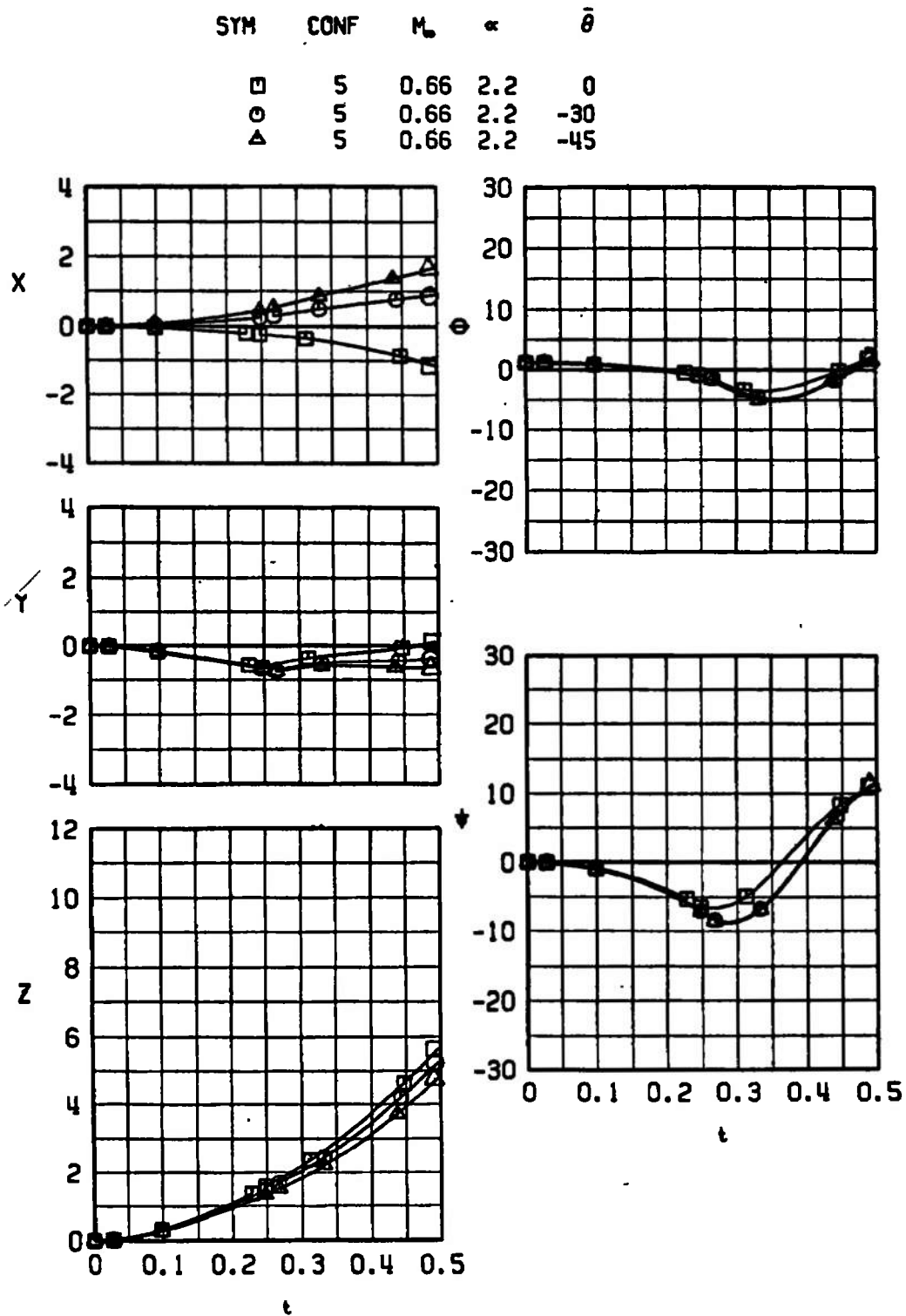
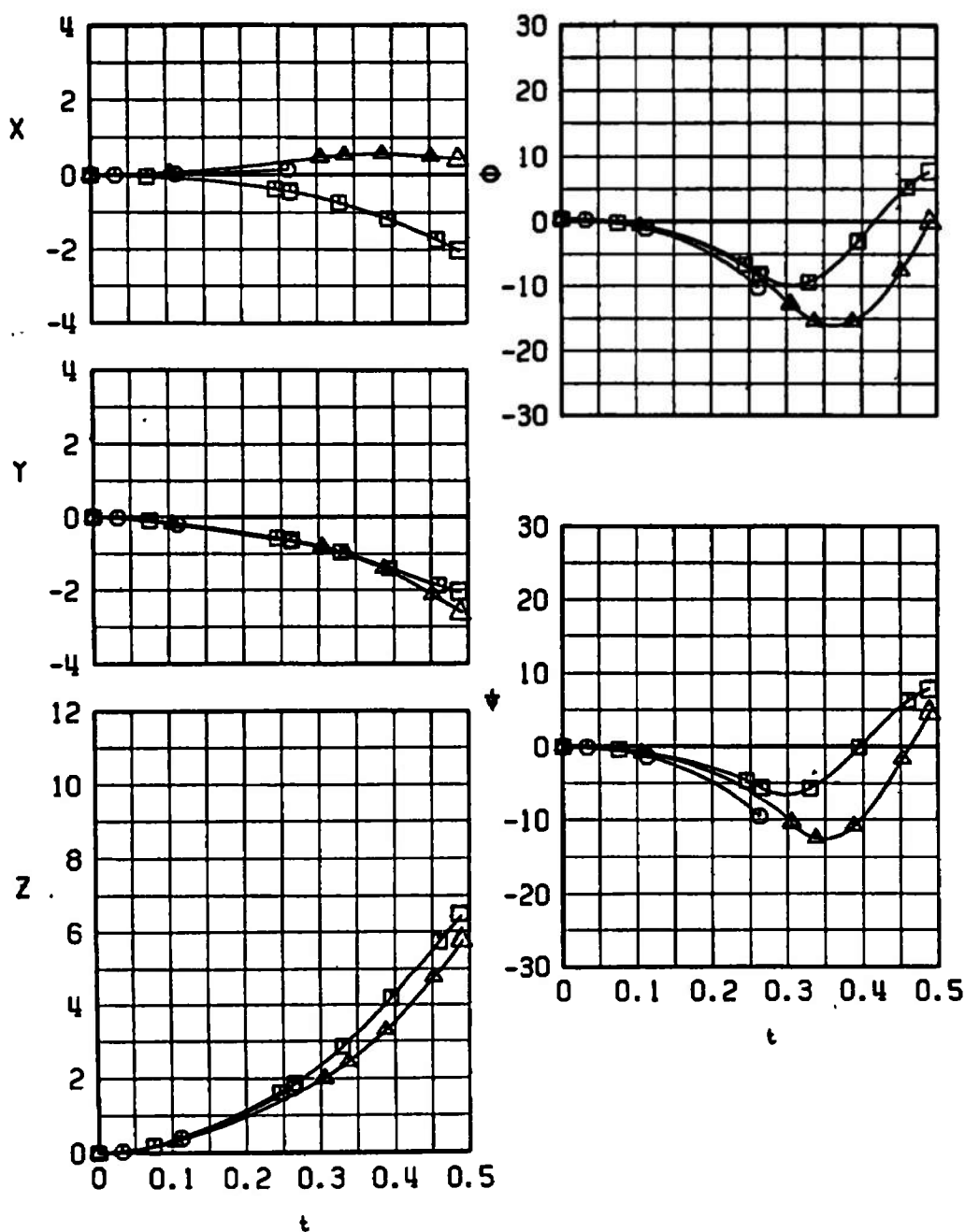
a.  $M_\infty = 0.66$ 

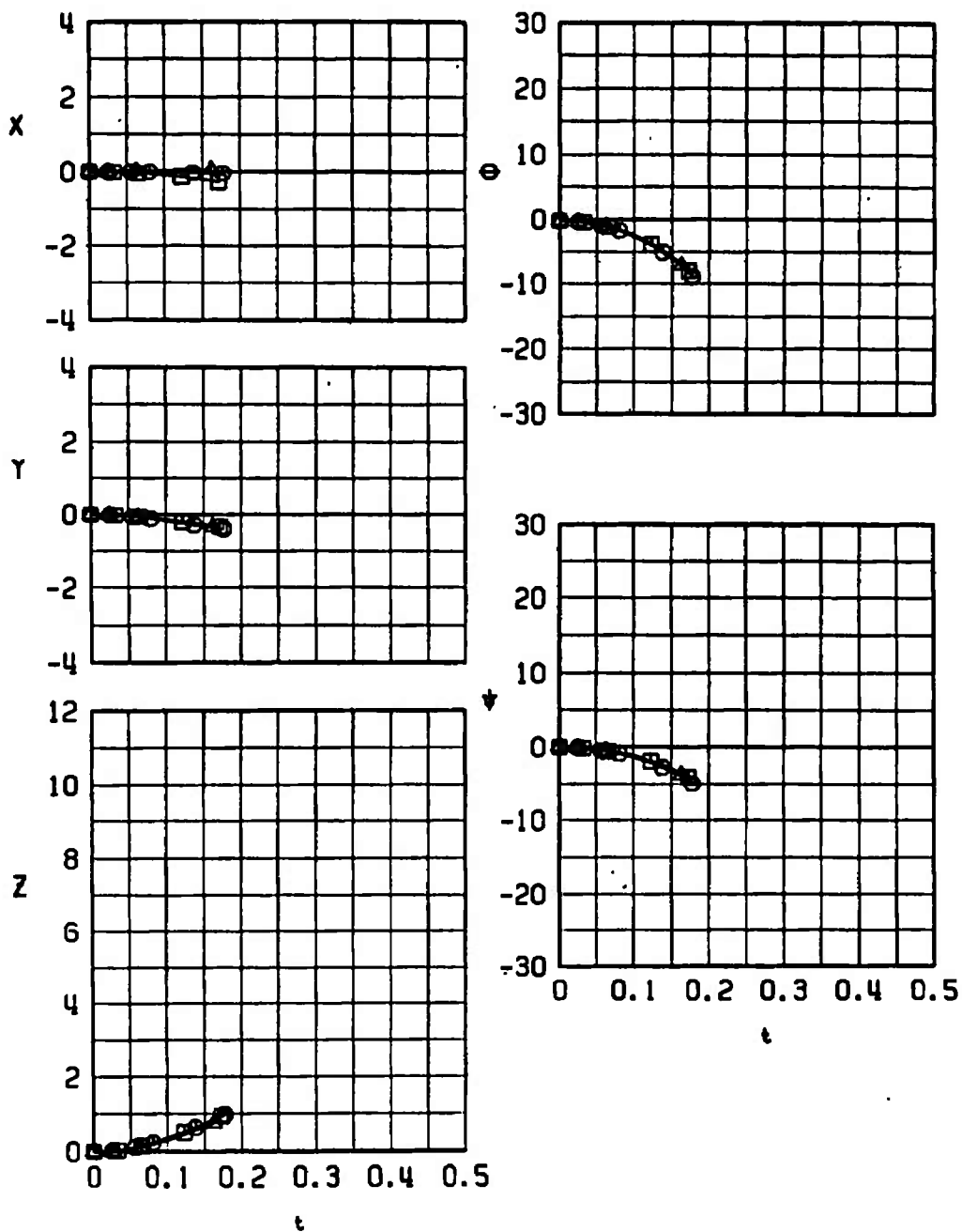
Fig. 18 Separation Trajectory Data for Configuration 5

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	5	0.74	1.4	0
○	5	0.74	1.4	-30
△	5	0.74	1.4	-45



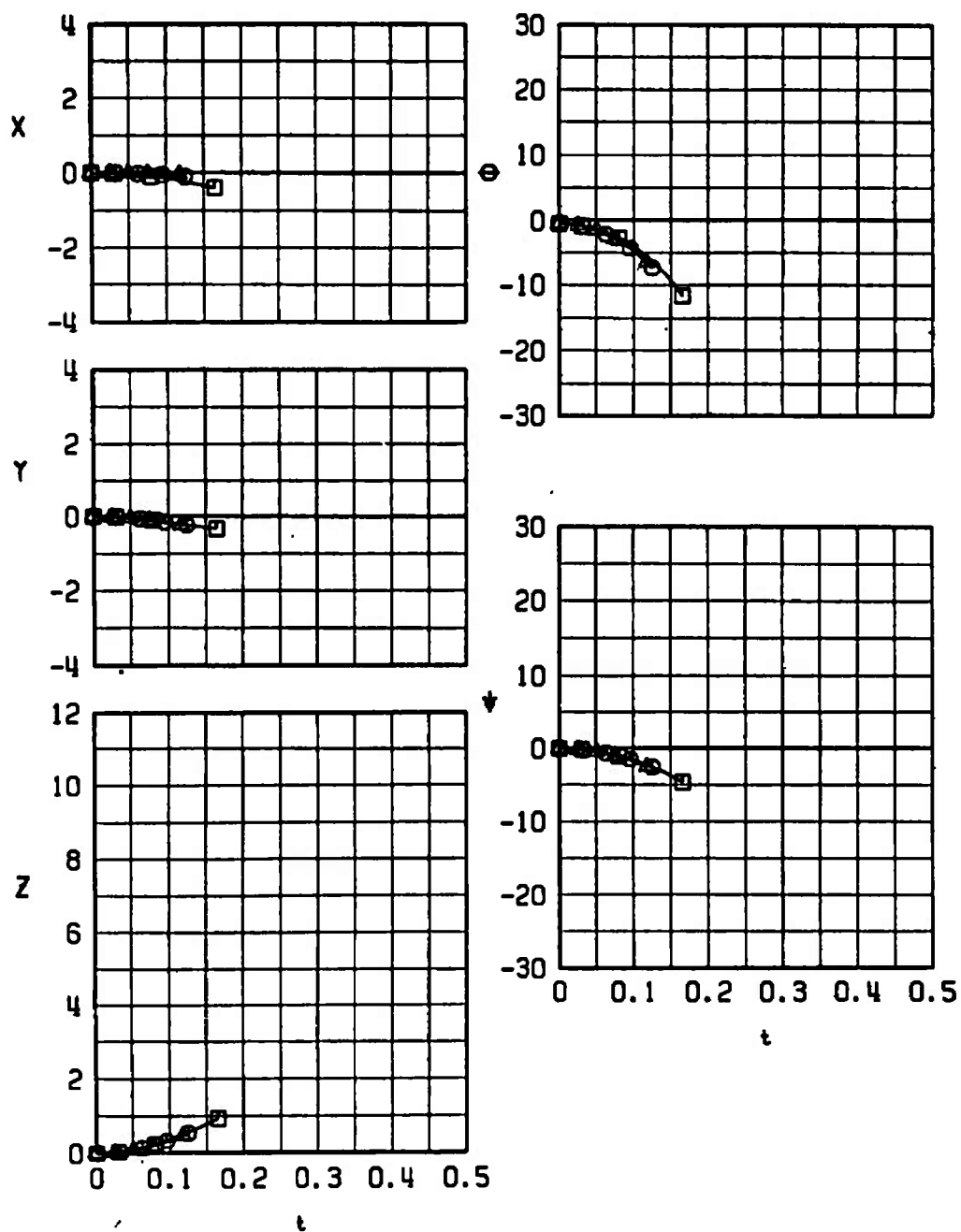
b.  $M_\infty = 0.74$   
Fig. 18 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	5	0.82	0.8	0
○	5	0.82	0.8	-30
△	5	0.82	0.8	-45



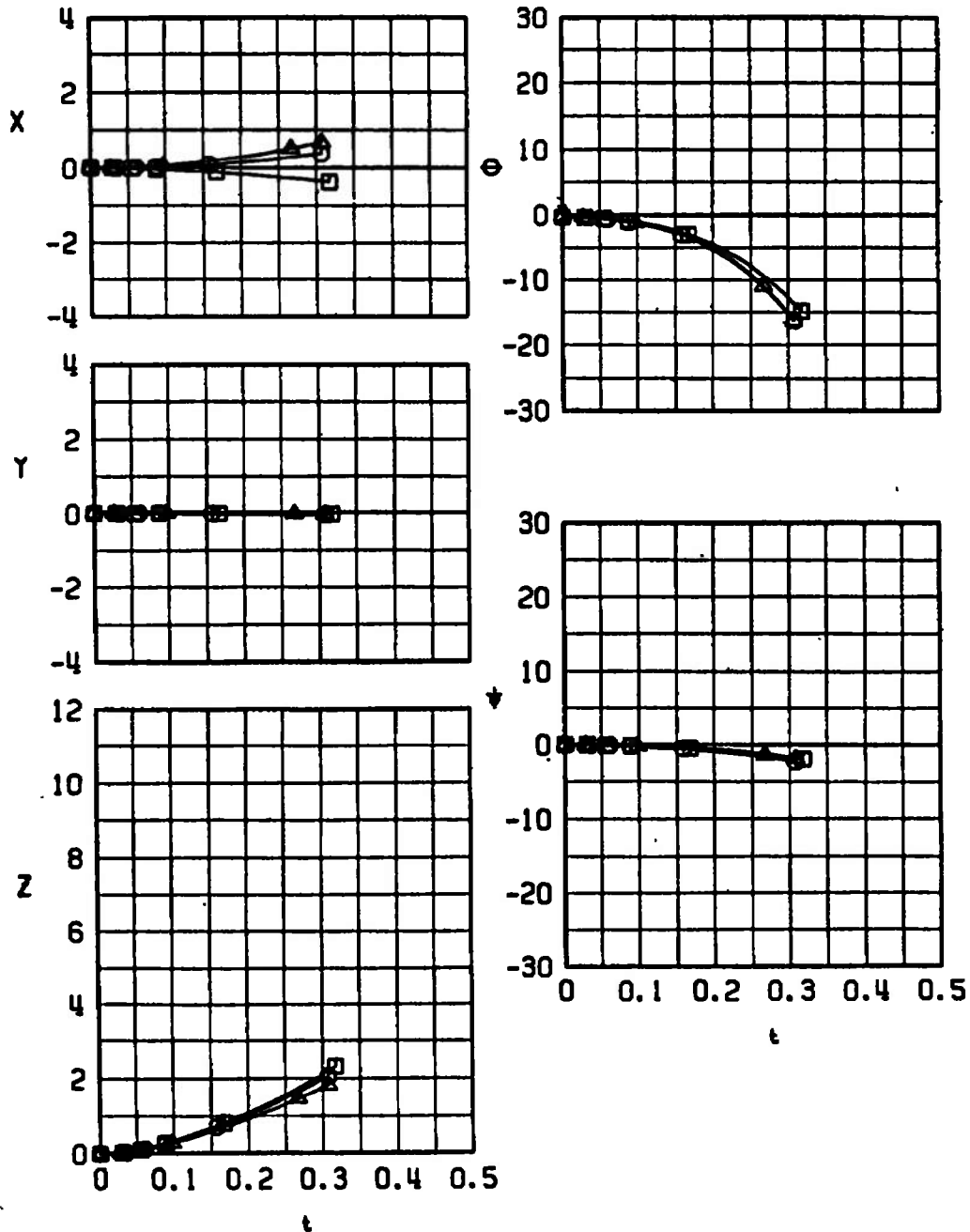
c.  $M_\infty = 0.82$   
Fig. 18 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	5	0.90	0.5	0
○	5	0.90	0.5	-30
△	5	0.90	0.5	-45



d.  $M_\infty = 0.90$   
Fig. 18 Concluded

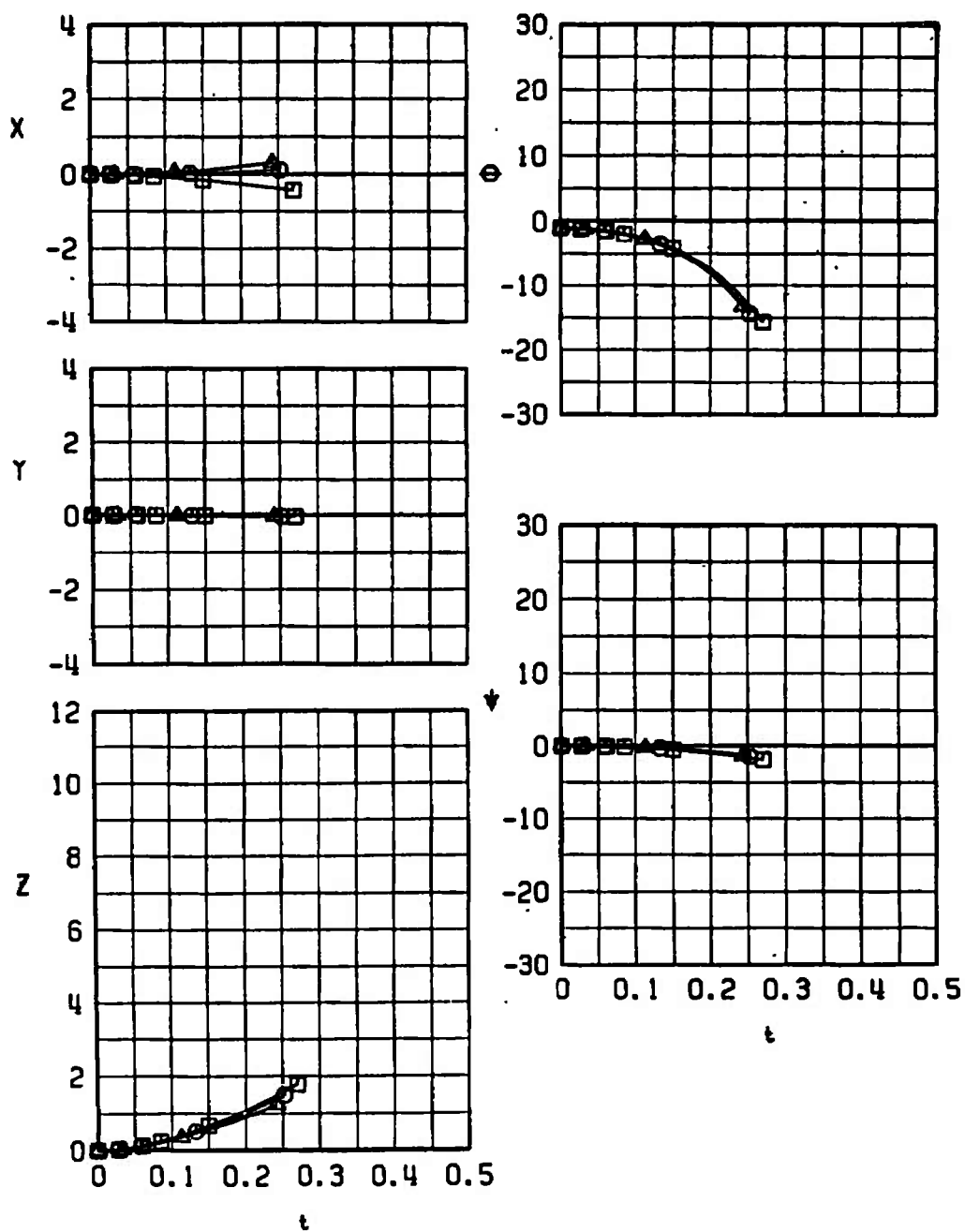
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	6	0.66	2.2	0
○	6	0.66	2.2	-30
△	6	0.66	2.2	-45



a.  $M_\infty = 0.66$

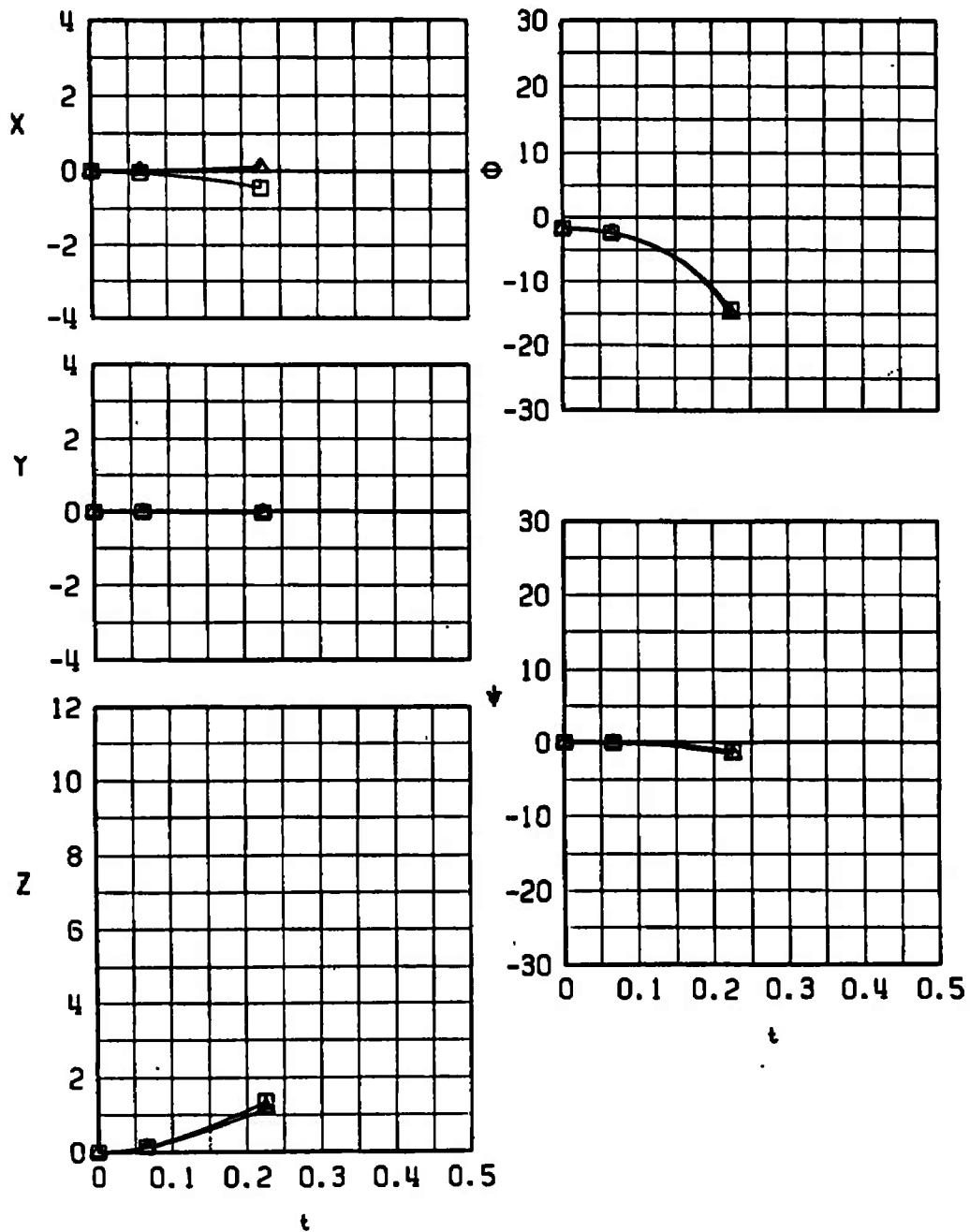
Fig. 19 Separation Trajectory Data for Configuration 6

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	6	0.74	1.4	0
○	6	0.74	1.4	-30
△	6	0.74	1.4	-45



b.  $M_\infty = 0.74$   
Fig. 19 Continued

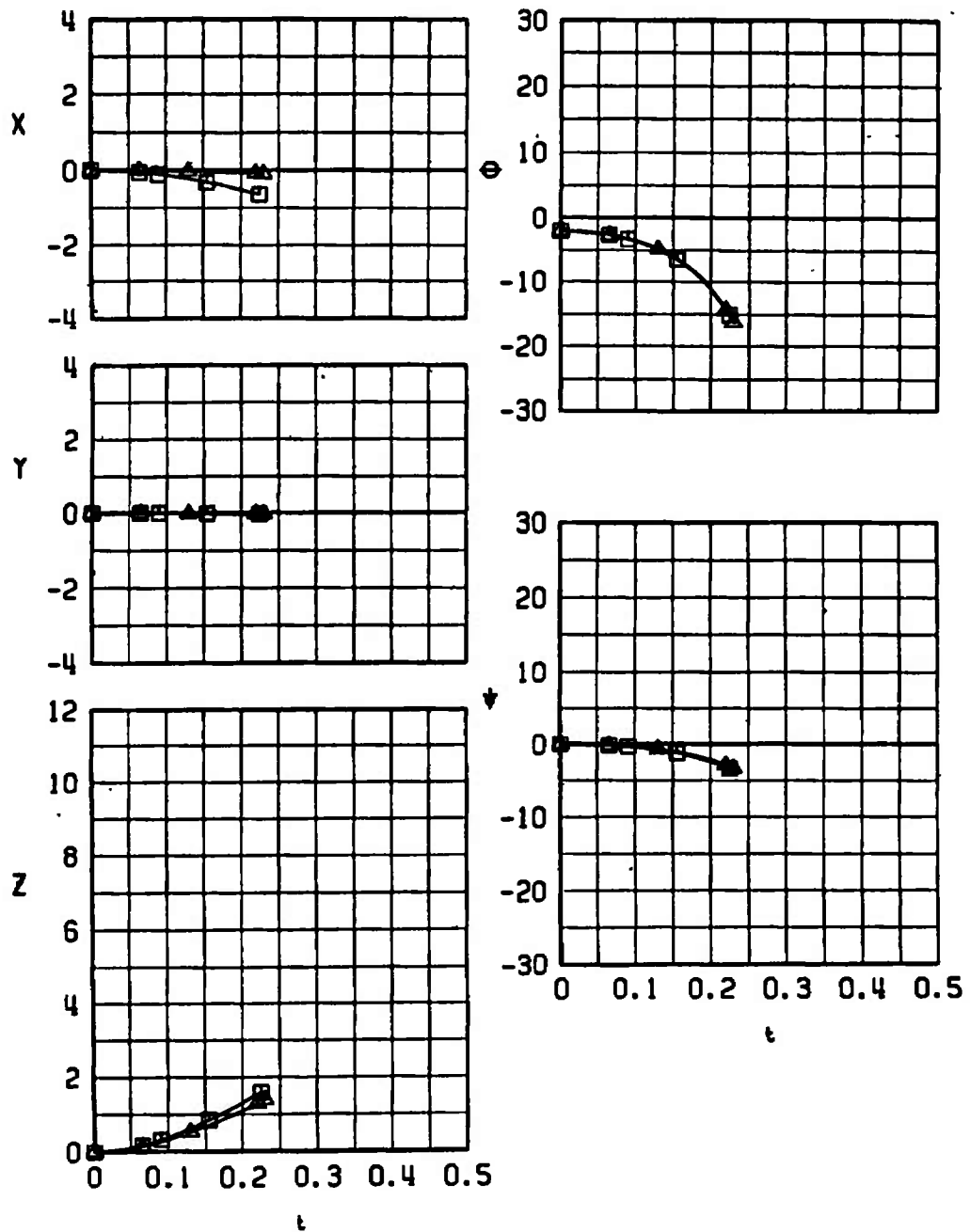
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	6	0.82	0.8	0
△	6	0.82	0.8	-45



c.  $M_\infty = 0.82$   
Fig. 19 Continued

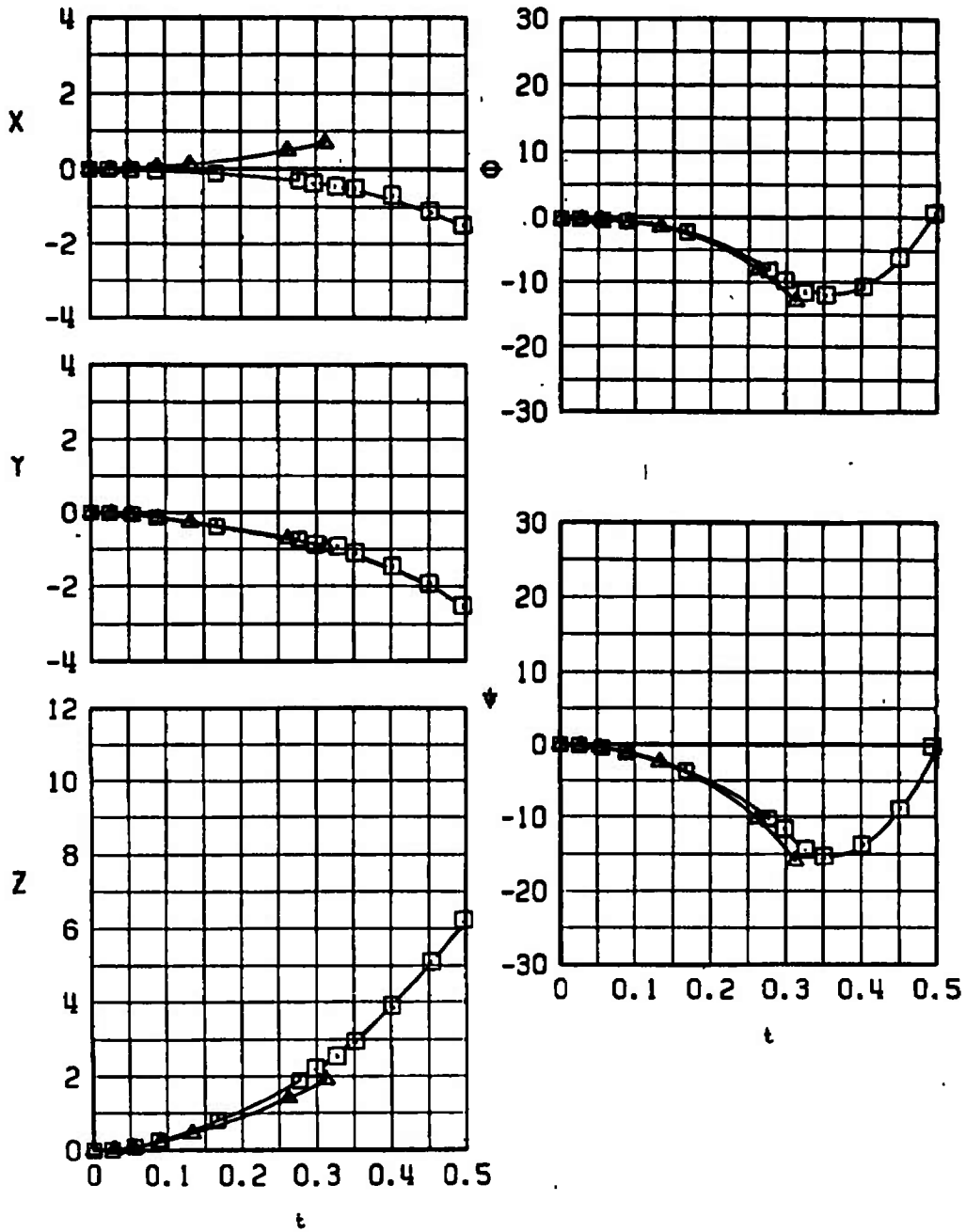


SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	6	0.90	0.5	0
△	6	0.90	0.5	-45



d.  $M_\infty = 0.90$   
Fig. 19 Concluded

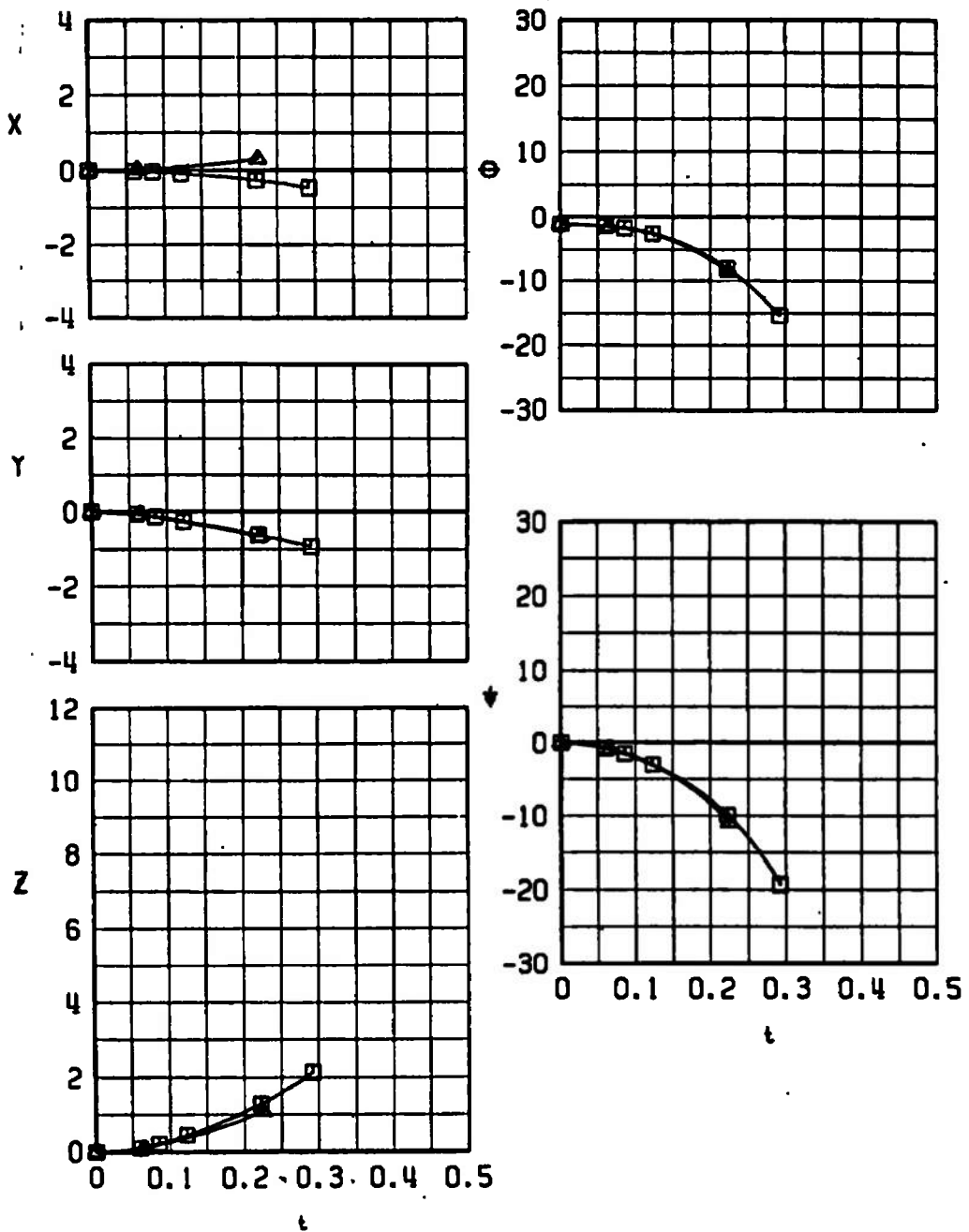
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	7	0.66	2.2	0
△	7	0.66	2.2	-45



a.  $M_\infty = 0.66$

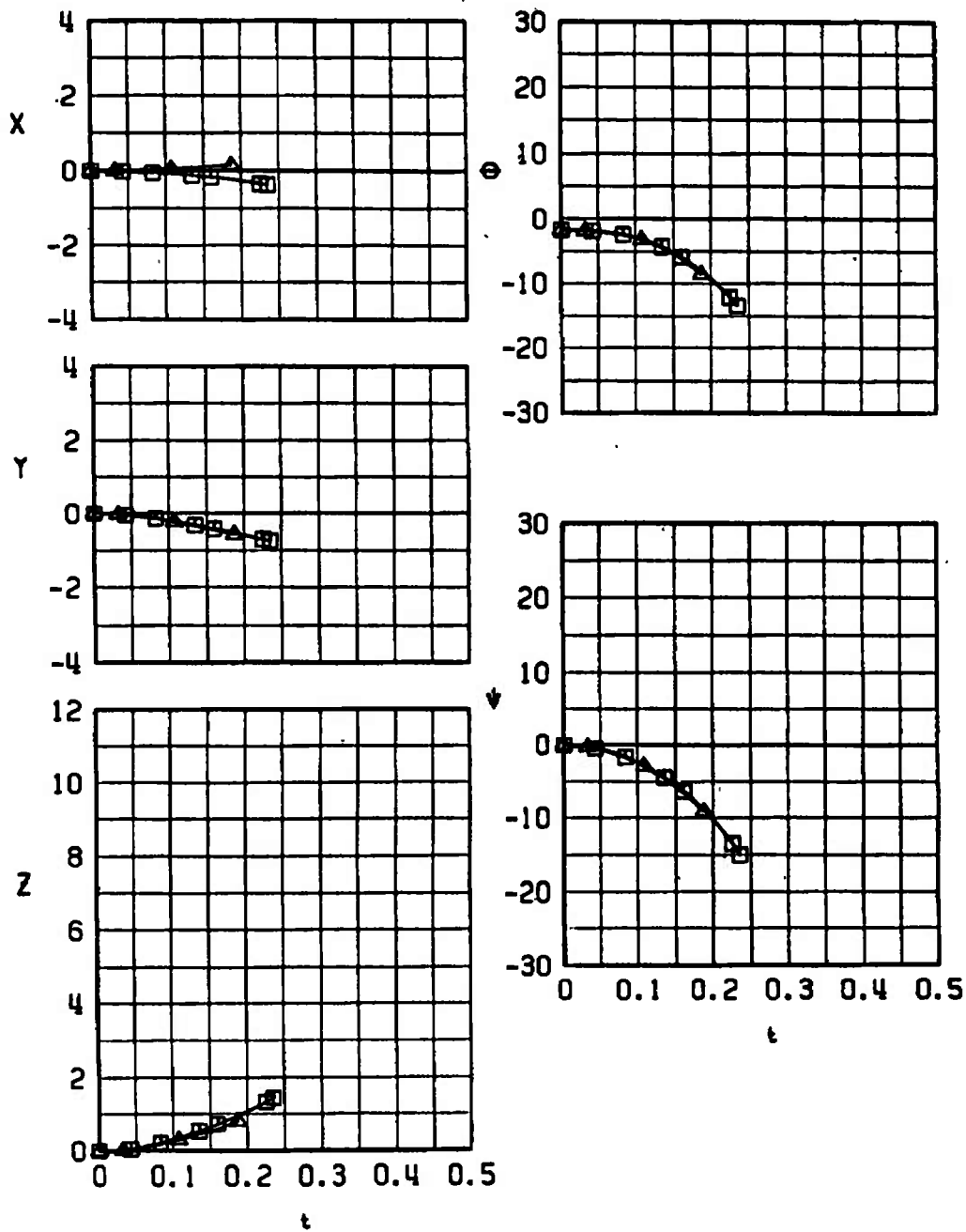
Fig. 20 Separation Trajectory Data for Configuration 7

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	7	0.74	1.4	0
△	7	0.74	1.4	-45



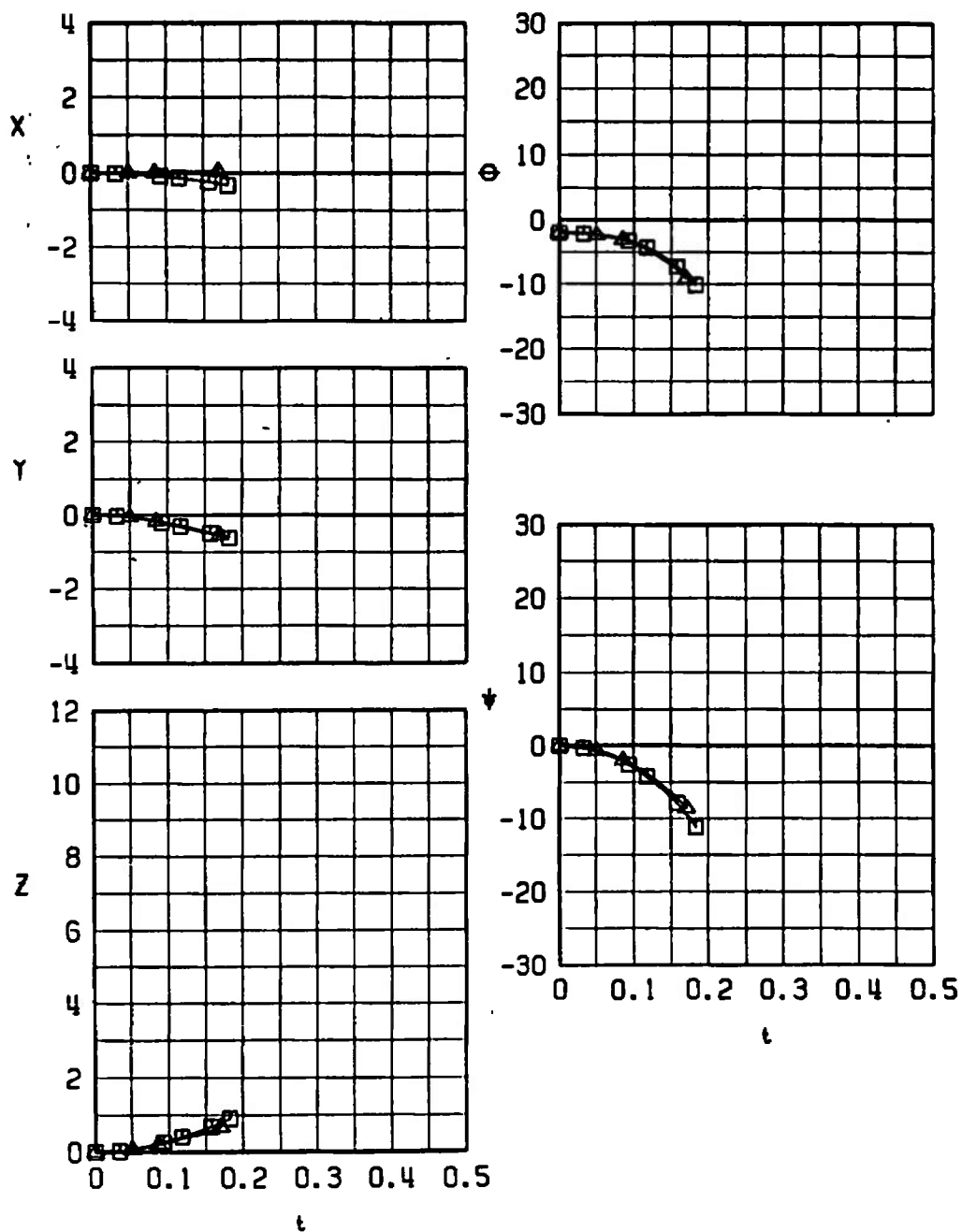
b.  $M_\infty = 0.74$   
Fig. 20 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	7	0.82	0.8	0
△	7	0.82	0.8	-45



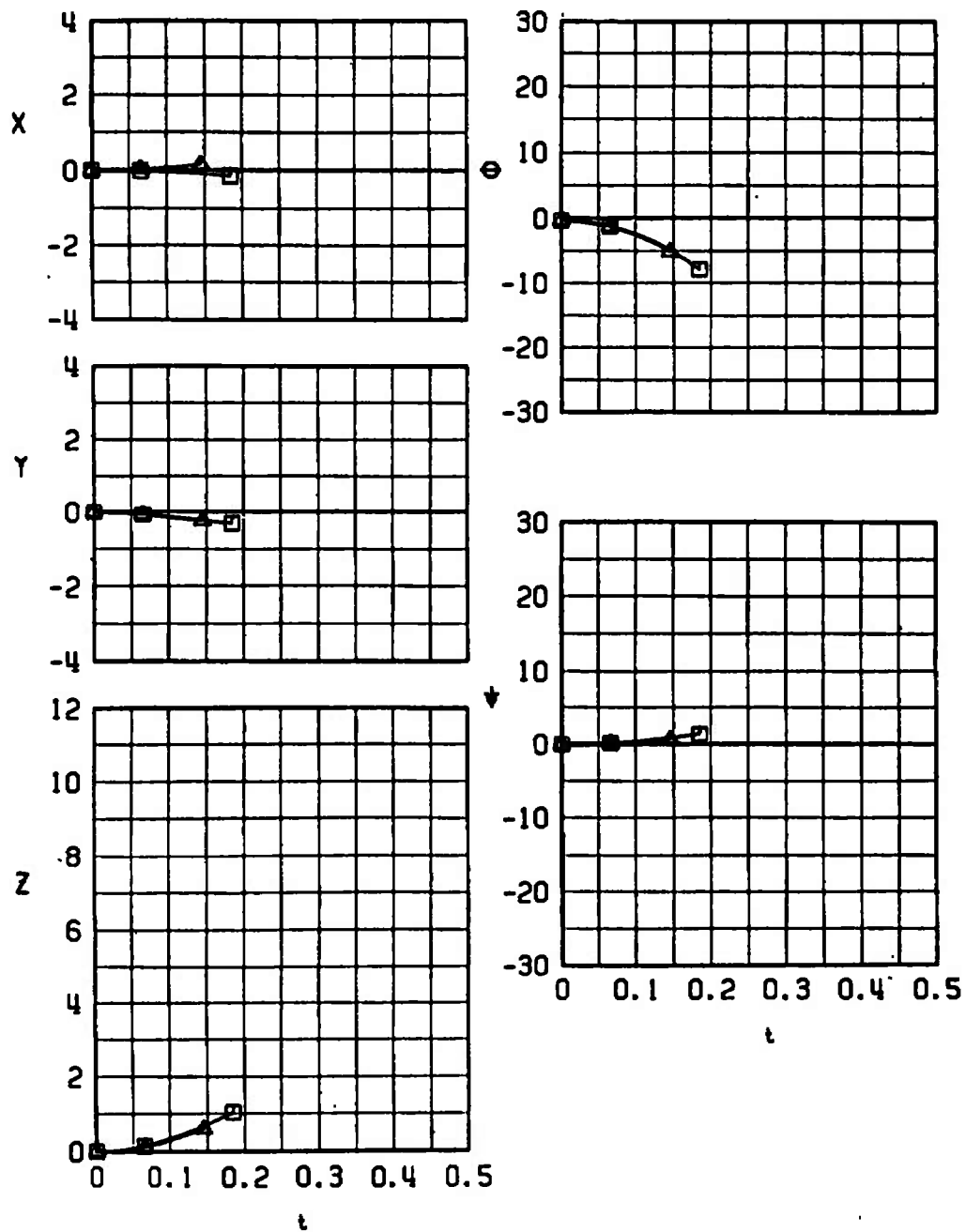
c.  $M_\infty = 0.82$   
Fig. 20 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	7	0.90	0.5	0
△	7	0.90	0.5	-45



d.  $M_\infty = 0.90$   
Fig. 20 Concluded

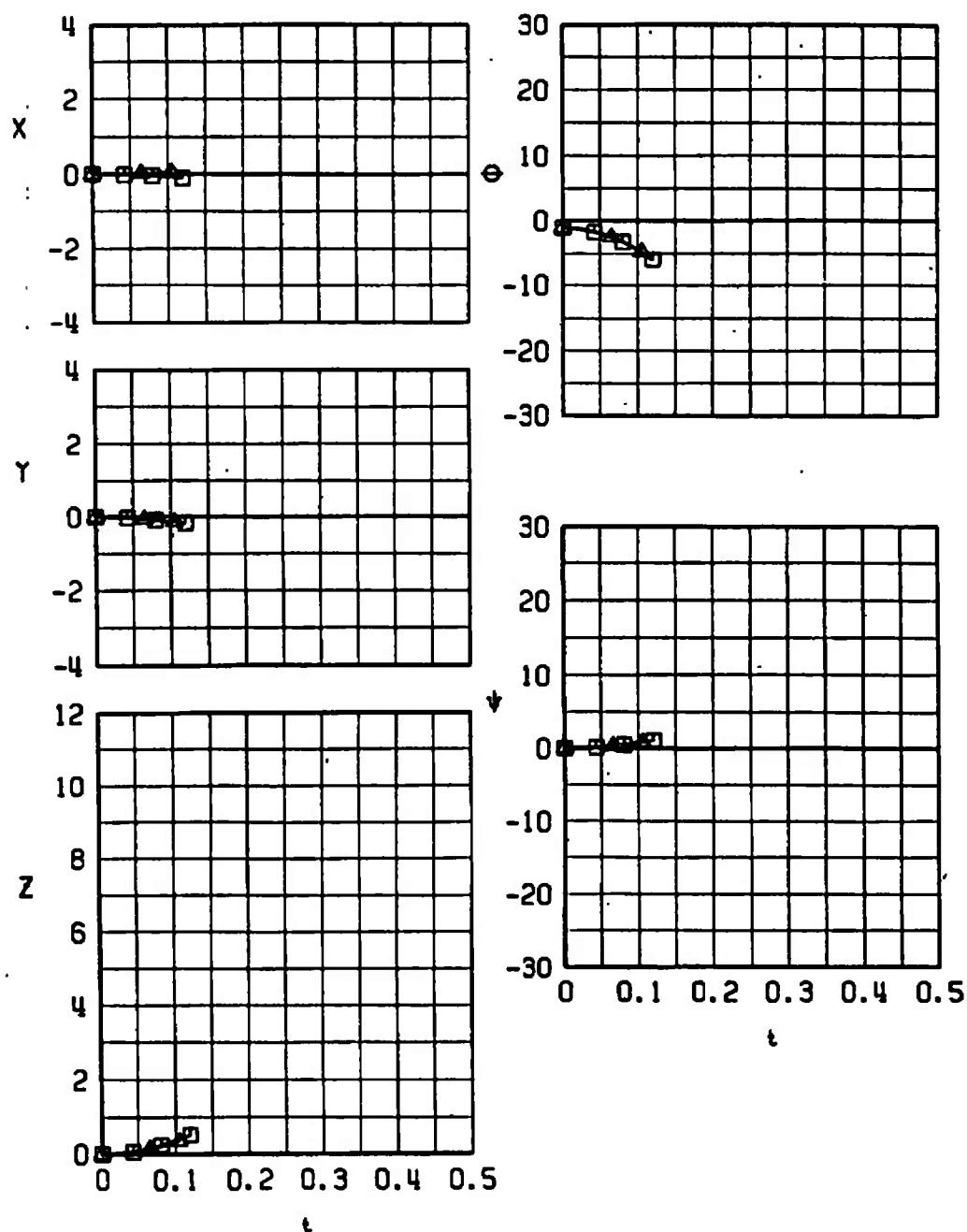
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	8	0.66	2.2	0
△	8	0.66	2.2	-45



a.  $M_\infty = 0.66$

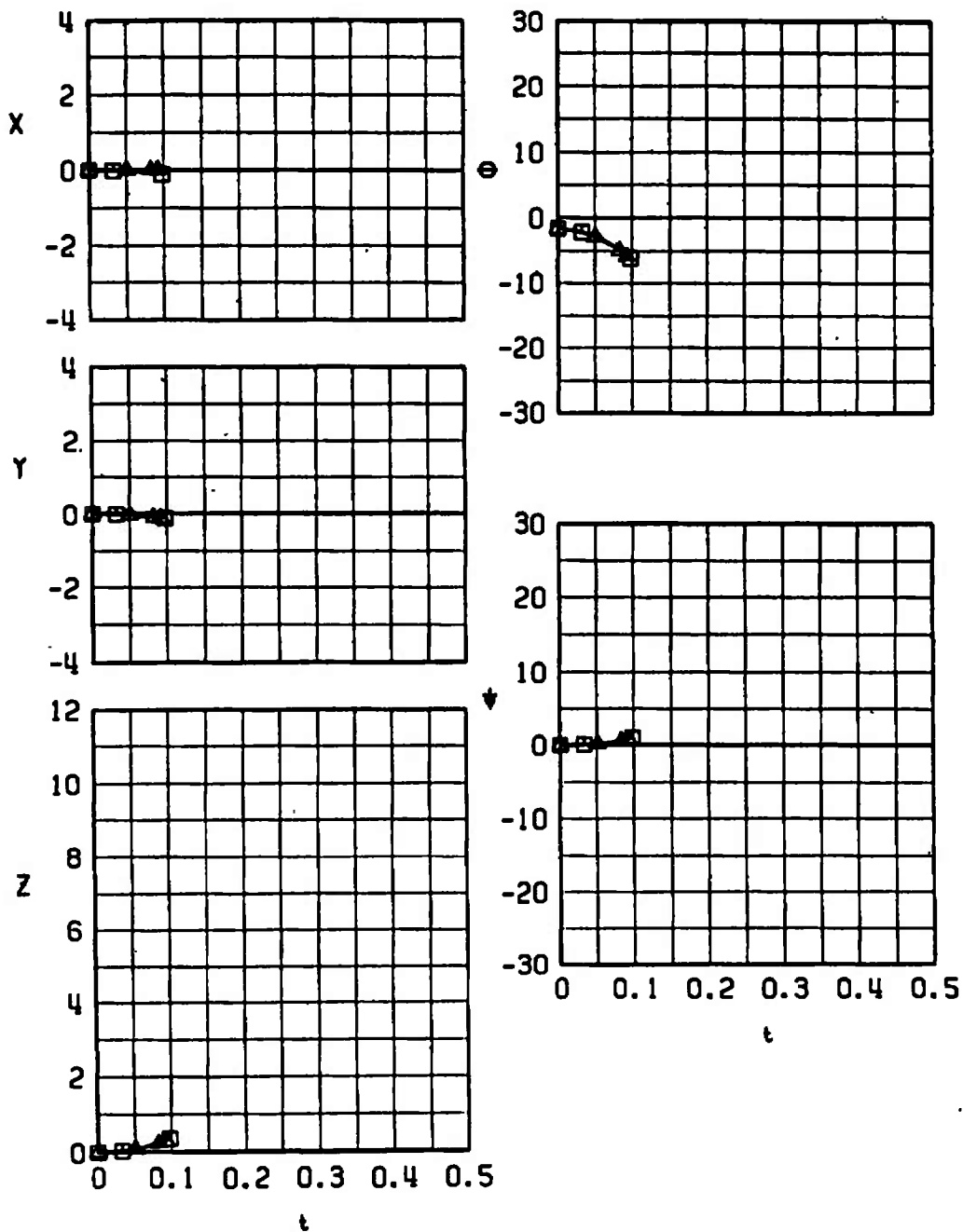
Fig. 21 Separation Trajectory Data for Configuration 8

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	8	0.74	1.4	0
△	8	0.74	1.4	-45



b.  $M_\infty = 0.74$   
Fig. 21 Continued

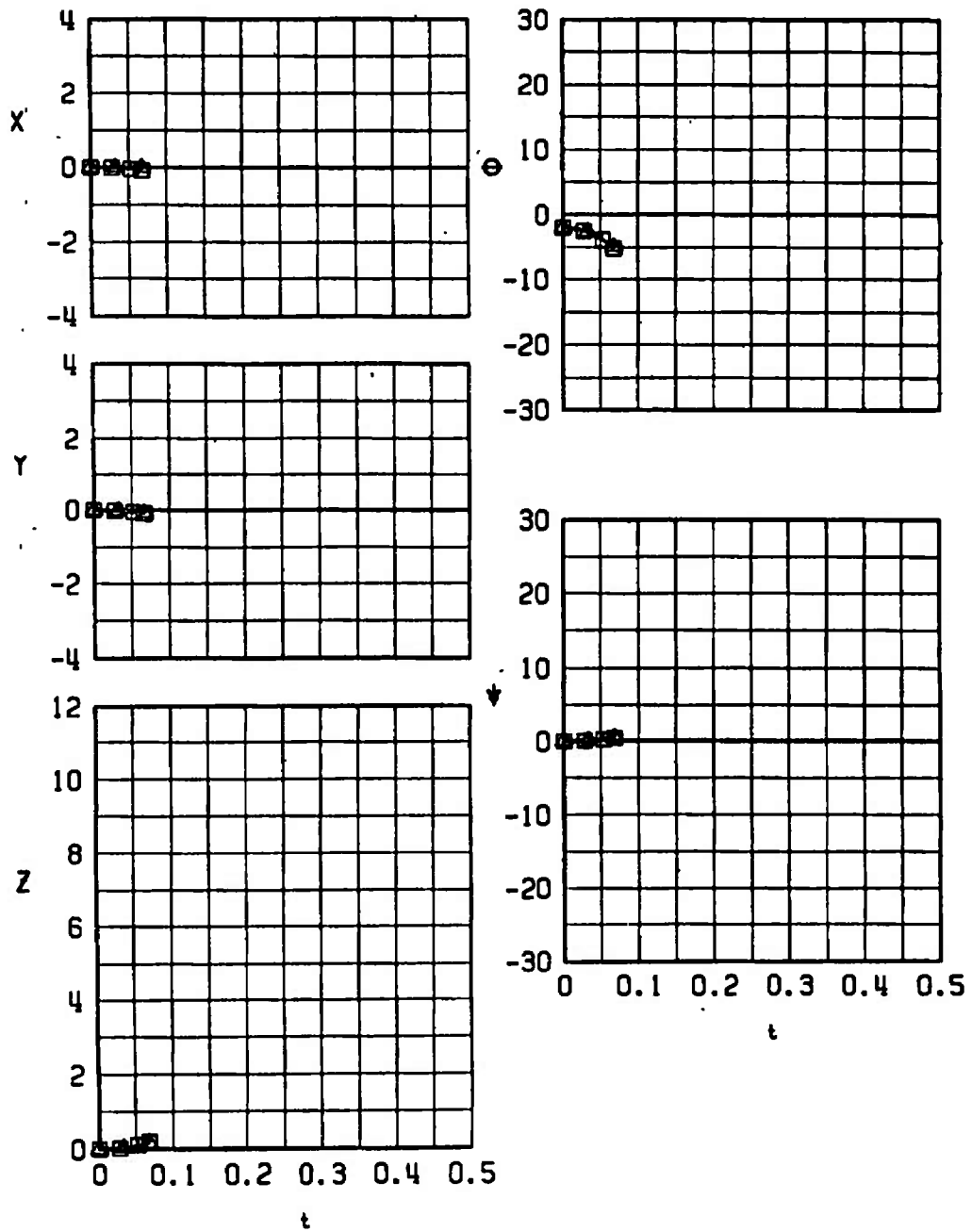
SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
$\square$	8	0.82	0.8	0
$\Delta$	8	0.82	0.8	-45



c.  $M_\infty = 0.82$   
Fig. 21 Continued



SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	8	0.90	0.5	0
△	8	0.90	0.5	-45



d.  $M_\infty = 0.90$   
Fig. 21 Concluded

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	9	0.66	2.2	0
△	9	0.66	2.2	-45

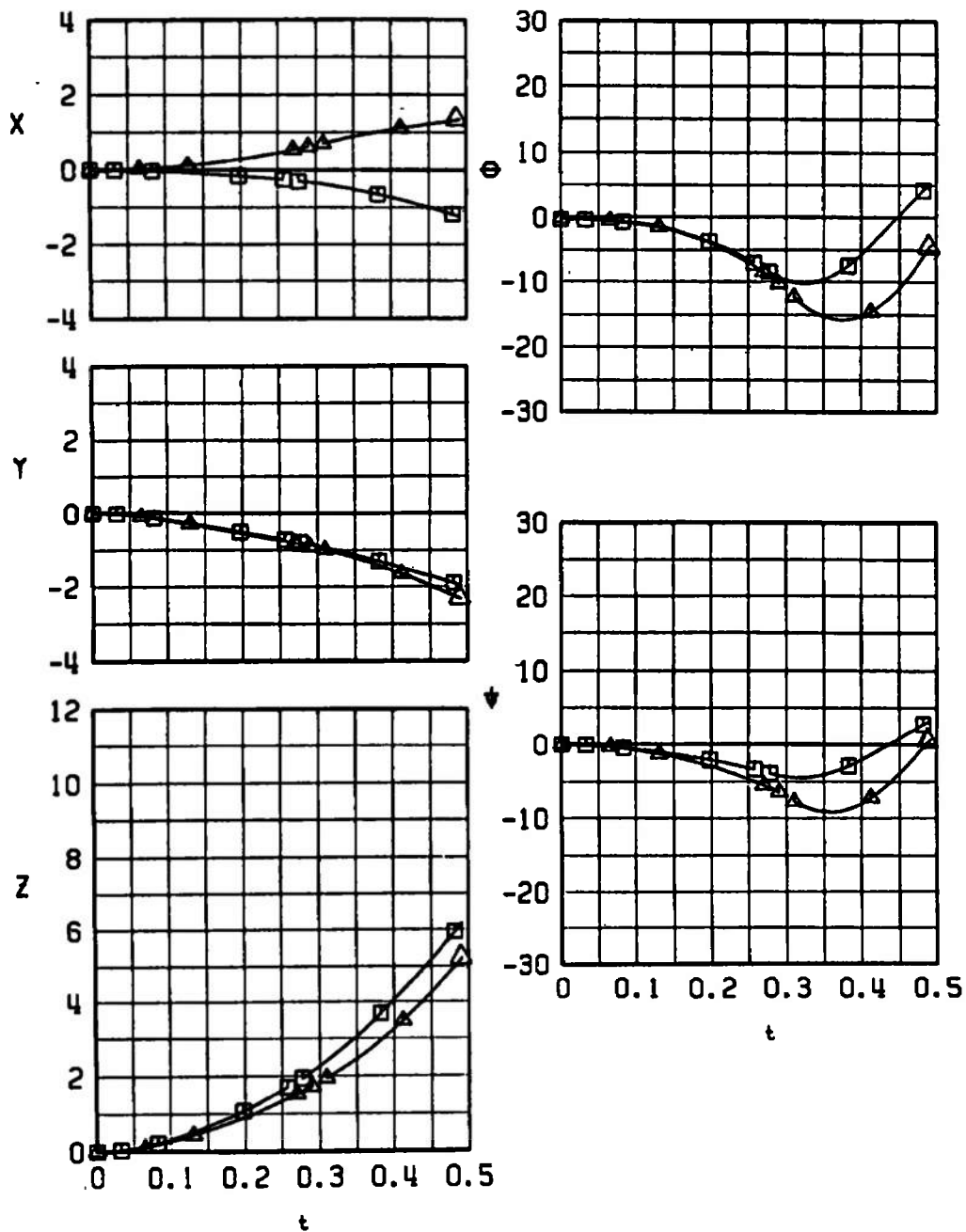
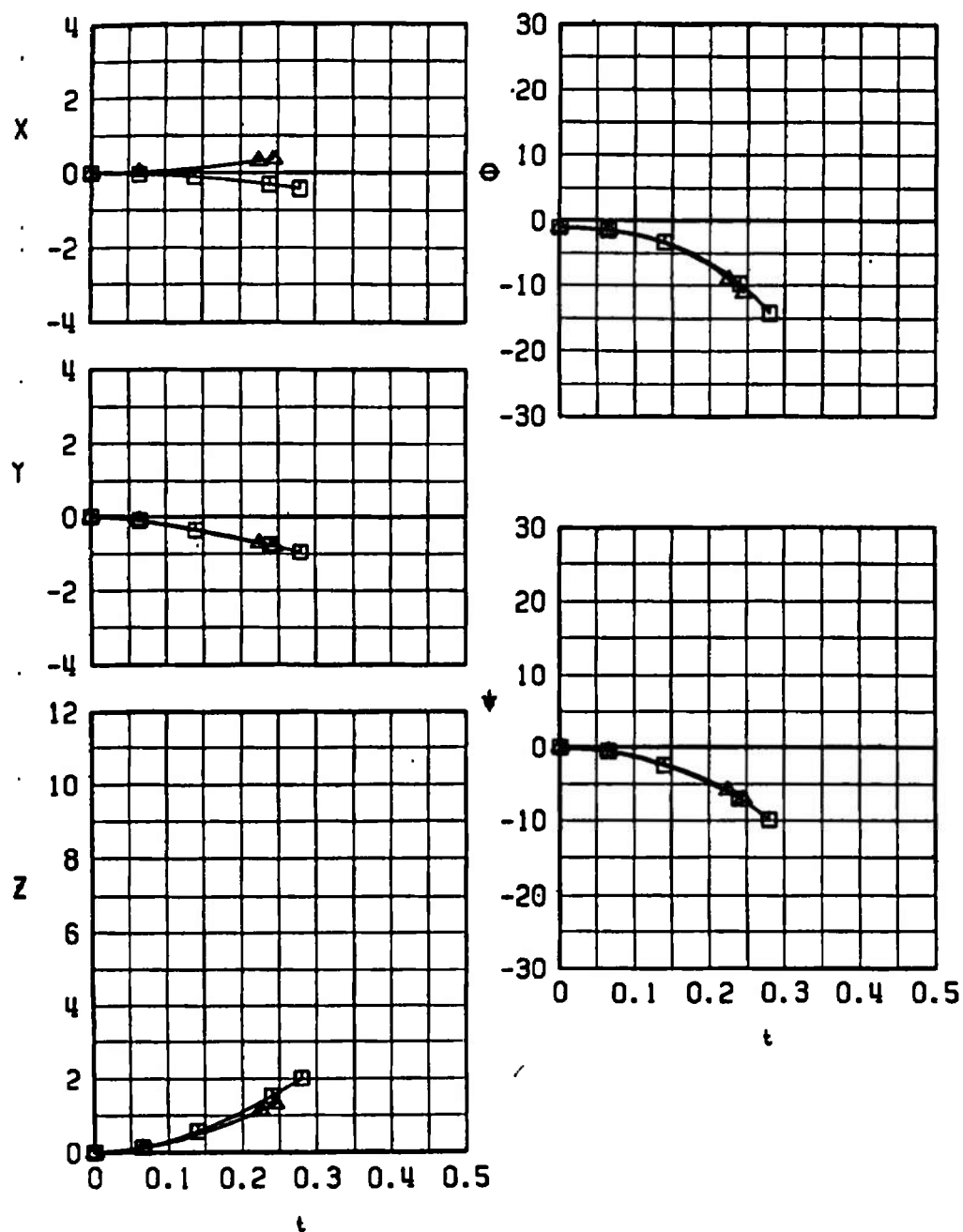
a.  $M_\infty = 0.66$ 

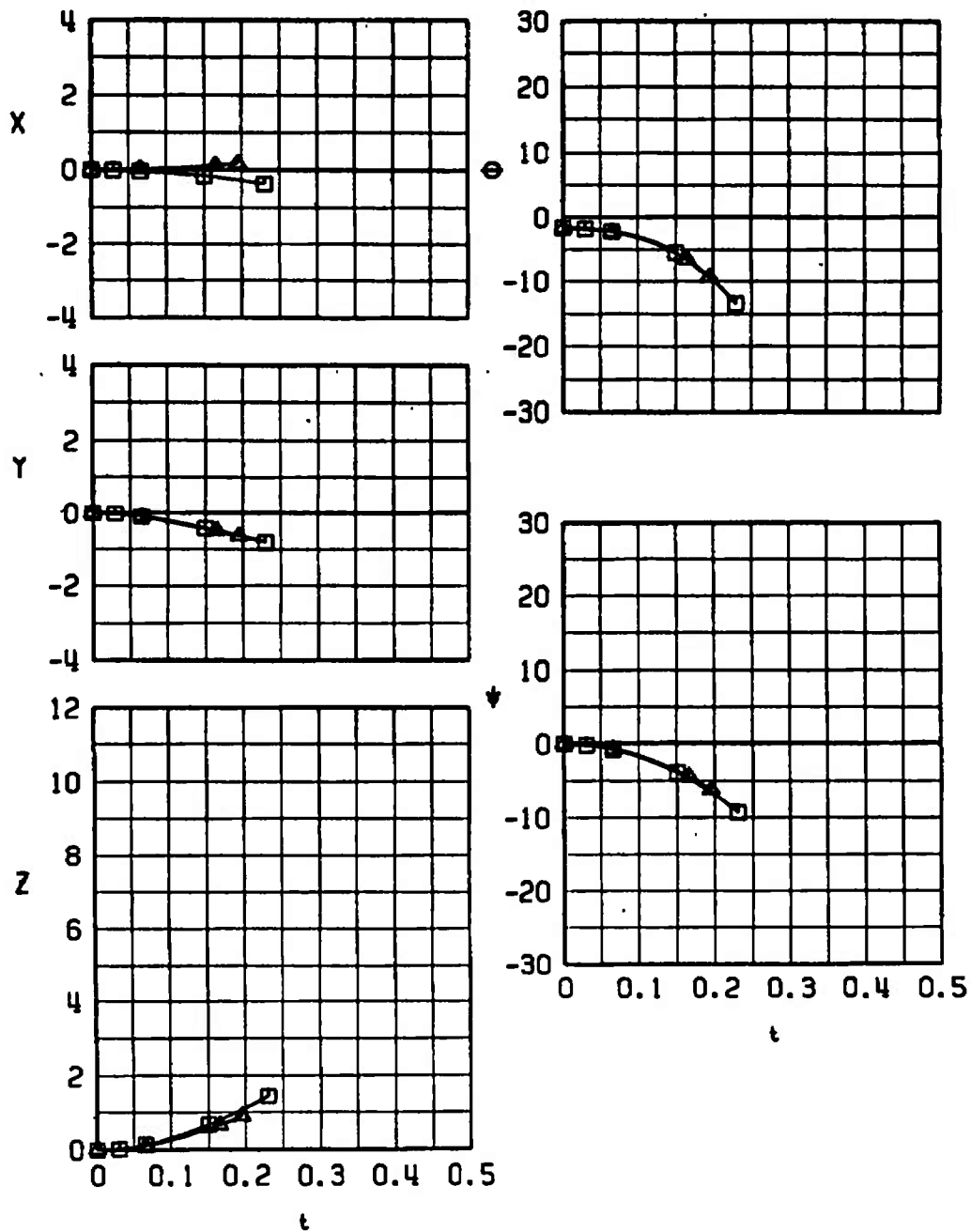
Fig. 22 Separation Trajectory Data for Configuration 9

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	9	0.74	1.4	0
△	9	0.74	1.4	-45



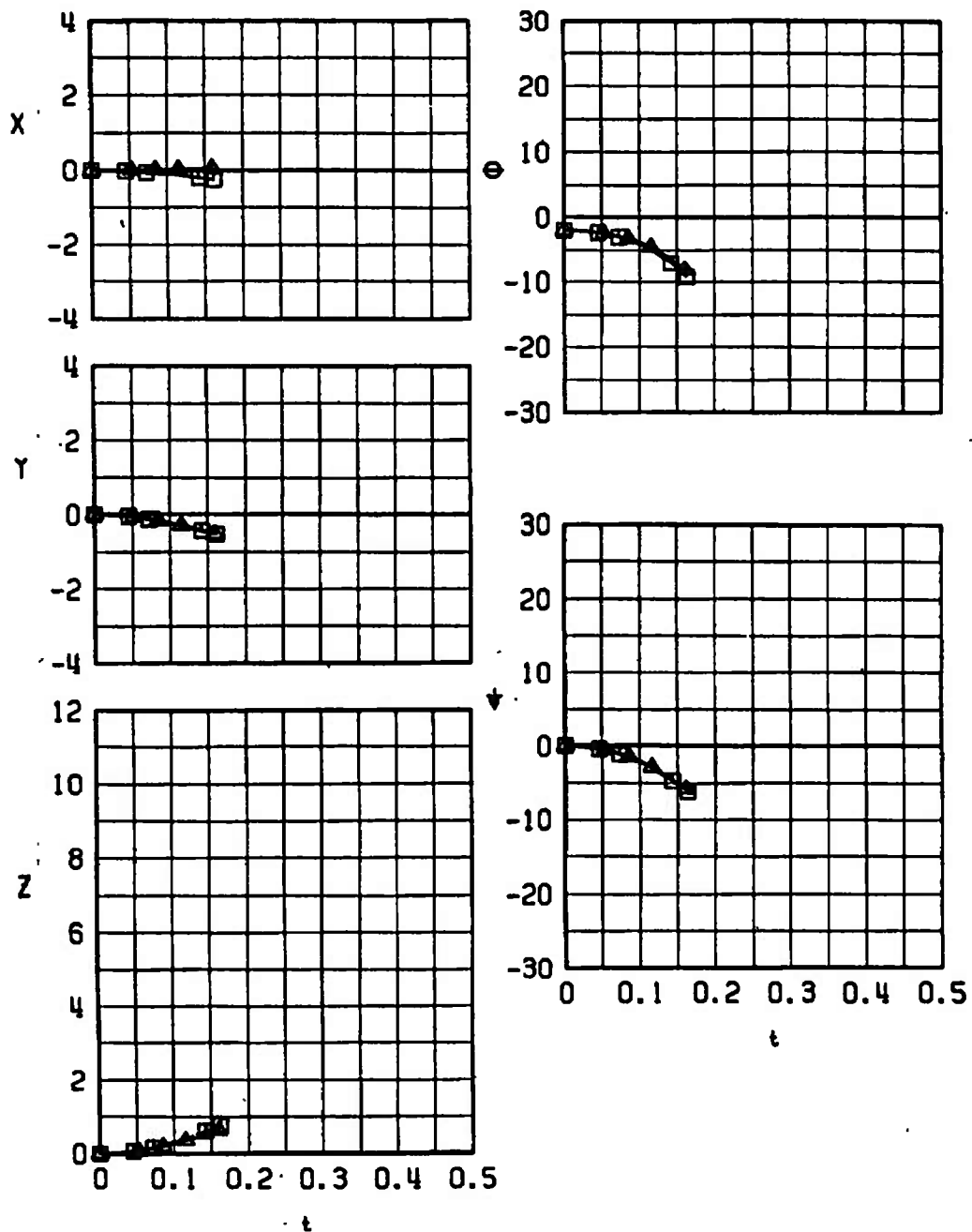
b.  $M_\infty = 0.74$   
Fig. 22 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	9	0.82	0.8	0
△	9	0.82	0.8	-45



c.  $M_\infty = 0.82$   
Fig. 22 Continued

SYM	CONF	$M_\infty$	$\alpha$	$\bar{\theta}$
□	9	0.90	0.5	0
△	9	0.90	0.5	-45



d.  $M_\infty = 0.90$   
Fig. 22 Concluded

TABLE I  
FULL-SCALE STORE PARAMETERS USED IN THE TRAJECTORY CALCULATIONS

Parameter	Folded Fin Configuration	Deployed Fin Configuration
Mass, $\bar{m}$ , slugs	25.590	25.590
Center-of-gravity location, $X_{cg}$ , ft	4.000	4.000
Ejector piston location, $X_L$ , ft	-0.0785	
Ejector stroke length, $Z_E$ , ft	0.2552	
Distance of the store cg above the store axial centerline, ft	0.0180	0.0180
Store reference area, $S$ , ft <sup>2</sup>	1.3963	1.3963
Store reference diameter, $b$ , ft	1.3330	1.3330
Pitch moment of inertia, $I_{yy}$ , slugs-ft <sup>2</sup>	71.8170	71.8170
Yaw moment of inertia, $I_{zz}$ , slugs-ft <sup>2</sup>	71.5360	71.5360
Product of inertia, $I_{xz}$ , slugs-ft <sup>2</sup>	0	0
Pitch damping derivative, $C_{mq}$ , per radian	-9.0	-60.0
Yaw damping derivative, $C_{nr}$ , per radian	-9.0	-60.0

**TABLE II**  
**MAXIMUM FULL-SCALE POSITION UNCERTAINTIES RESULTING**  
**FROM BALANCE PRECISION LIMITATIONS**

$M_0$	t, sec	$\Delta X$ , ft	$\Delta Y$ , ft	$\Delta Z$ , ft	$\Delta \theta$ , deg	$\Delta \psi$ , deg
0.66	0.3	0.02	0.02	0.01	0.2	0.3
0.66	0.5	0.05	0.05	0.03	0.5	0.8
0.90	0.3	0.04	0.04	0.02	0.4	0.6
0.90	0.5	0.10	0.10	0.05	1.0	1.6

**TABLE III  
FIN DEPLOYMENT**

Configuration	$M_\infty$	$\alpha_p$	$\bar{\theta}$	Presented in Figure No.	Time at Which Fins Were Deployed, sec
1	0.66	2.2	0	14a	0.3100
2	0.66	2.2	0	15a	0.2750
2	0.66	2.2	-30	15a	0.2800
2	0.66	2.2	-45	15a	0.2800
4	0.66	2.2	0	17	0.2650
4	0.66	2.2	-30	17	0.2250
5	0.66	2.2	0	18a	0.2475
5	0.66	2.2	-30	18a	0.2675
5	0.66	2.2	-45	18a	0.2675
5	0.74	1.4	0	18b	0.2650
5	0.74	1.4	-45	18b	0.3050
7	0.66	2.2	0	20a	0.2975
9	0.66	2.2	0	22a	0.2775
9	0.66	2.2	-45	22a	0.3100



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13. ABSTRACT <p>A wind tunnel test was conducted using 0.05-scale models to study the separation characteristics of the SUU-51/B from the F-4C aircraft. The separation trajectories were initiated from the left-wing inboard pylon station utilizing the Triple Ejection Rack and from the centerline pylon utilizing the Multiple Ejection Rack. The flight conditions simulated were Mach numbers from 0.66 to 0.90 at an altitude of 5000 ft. Parent aircraft dive angles of 0, 30, and 45 deg were simulated.</p> <p><b>Distribution limited to U. S. Government agencies only; this report contains information on test and evaluation of military hardware; July 1971; other requests for this document must be referred to Armament Development and Test Center (DLGD), Eglin AFB, Florida 32542.</b></p> <p>This document has been approved for public release its distribution is unlimited TAB 74-11 H'd 24 May 74</p>			

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